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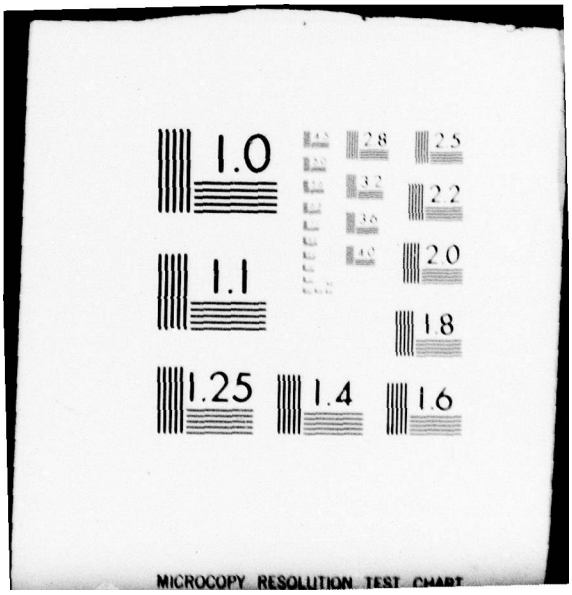
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METHODOLOGY NOTEBOOK FOR ACTION OFFICERS

PART II

VISION TO VICTORY

OPERATIONS RESEARCH/SYSTEMS ANALYSIS
COURSE FOR EXECUTIVES
U. S. ARMY MANAGEMENT SCHOOL
FORT BELVOIR, VIRGINIA

AUGUST 1968

August 1968

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FOR THE CHIEF:

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FOREWORD

Much has been written concerning the mission, purposes, functions, and policies of USACDC Combat Support Group. Practically all the published matter, however, is in the form of regulations, pamphlets, and policy edicts pertaining to individual operational or functional areas. None of these published documents provides quick and easy insight into the interaction within and among USACDCCSG divisions in the staffing of a given operational study.

This pamphlet does not change existing policy, nor does it establish new policy or procedure. Rather, it is intended to convey a meaningful portrait of how operations research is employed at all levels of command to arrive at scientific solutions to operational problems. More specifically, this document ties together the operational functions within USACDCCSG, relates them to the overall Combat Developments program, clarifies Combat Support Group divisional responsibilities and, insofar as practical, identifies the sequential staffing order of a given study or project. Particular emphasis is placed on operations research procedures and techniques and their application.

The format and contents of this book have been selected to meet a threefold objective: (1) It must augment and supplement Part I of the USACDC Methodology Notebook for Action Officers; (2) It must be useful, illustrative, and adaptable to the needs of USACDCCSG and assigned agencies; (3) It must be kept current, reflecting accepted methods and techniques for accomplishing combat support research.

Operations research in its entirety is a viable and dynamic area and, as such, is subject to constant improvements and changes. As greater numbers of individuals qualify in the field, more documentation will be provided to the field. As these additions and changes take place, this book will be updated. As stated above, this book was prepared to fulfill USACDC requirements of "Part II to the Methodology Notebook". Part III publication is the responsibility of each USACDC Agency, Part IV is the responsibility of applicable action officers. These latter two parts will be published later.

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APPLICATION OF OPERATIONS RESEARCH
IN THE
UNITED STATES ARMY

COMBAT DEVELOPMENTS COMMAND

COMBAT SUPPORT GROUP

CHAPTER 1

INTRODUCTION

1. Purpose. The purpose of this notebook is to complement Part I of the USACDC Methodology Notebook for Action Officers. The notebook is intended to convey a brief but comprehensive portrayal of how operations research is employed in the USACDC Combat Support Group to arrive at scientific solutions to Combat Support problems. It is not intended that it be a panacea for all problems, nor that it be used as a Standing Operating Procedure. Rather, it presents the policies, suggested methods of operation, organizational details, and tasks that are available to CSG action officers while it highlights the ways and means for these assets to be used in a scientific manner. Research within CSG is applied--not pure-- research. As such, it must be conducted with a view toward the scientific determination or identification of tangible end products--products that will be of scientifically proven benefit to the Army of the future. The material presented in this notebook is designed to provide USACDCCSG and assigned agency action officers with the basic fundamentals needed to perform CSG applied research.

2. Scope. This notebook is basic to functions of staff officers at USACDCCSG and within its assigned agencies. It is especially appropriate for the officer who is entering the Combat Developments field for the first time. Here, in logical sequence, he will find the genesis of the CSG role; the CSG organization; a definition of the various types of combat development studies and methods employed in conducting them; and a definitive compilation of tools and techniques employed in contractual research support management. By becoming familiar with the contents of this book and that of its forerunner, Part I, the new officer will acquire an invaluable base from which to expand his knowledge in the empirical methods and techniques. This book provides a background both for the producer of research concerned with a need to know scientifically derived factual information and for the

consumer of research interested in the interpretation and application of research findings. Although no text can provide full coverage of a field as broad as operations research, this book does provide an orientation to the nature of combat support research, the procedures by which it is conducted, and the crucial role it can play in advancing the effectiveness of the United States Army.

The Chapter on Cost Effectiveness is particularly noteworthy in view of its significance in a time and era when our nation must get the most for the taxpayer's money. Any action officer will eventually be faced with the need to conduct or review a Cost Effectiveness Analysis. This book provides him with a checklist of items necessary for conducting and/or evaluating such an analysis.

3. Operations Research. The means by which an action officer seeks the answers to his problem can be classified under three broad categories: experience, reasoning, and experimentation. These three categories are, of course, complementary and overlapping. Experimentation, for instance, is perhaps best conceived as a combination of experience and reasoning. The most primitive, and yet the most fundamental, source of solutions to most military problems lies in personal experience. This experience coupled with reasoning is frequently referred to as military judgment. The danger of the military-judgment approach is that frequently the decision-maker has only an inadequate, and perhaps inaccurate, conception of his experiences. History is replete with examples of battles lost because of mistakes in military judgment. The most sophisticated means by which an action officer attempts to arrive at factual conclusions is experimentation. The experimentation method consists of isolating the effects of the operation of a given factor by assigning that factor to one of two groups which are otherwise equal in all respects. The general pattern of using scientific techniques to solve problems is: certain phenomena are observed; a problem situation develops and is noted and clarified; crude relationships are tentatively identified and elaborated; a more or less formal hypothesis is derived; a design is developed to test the hypothesis; the hypothesis is verified or refuted; the results are subjected to further tests and refinement; and finally, the conclusions are integrated with the previous concepts of science. Military operations research applies the methods of science to the quantitative solution of military problems. Data and other information apparently relevant to the problem are assembled and examined and attempts are made to find cause-effect relationships or interdependence correlations. Although there is a long history of acceptance by military of the products of science and technology, it is only recently that the methods of science have been marshalled to assist in analyzing combat operations and developing military forces.

4. Essential characteristics of Operations Research. Operations research possesses several essential characteristics:

a. It adapts the inductive-deductive-demonstrative cycle of science to operational processes. In doing so, operations research may be said to consist of a back-and-forth movement in which the investigator first operates inductively from observations to hypotheses, and then deductively from these hypotheses to their implications in order to check their validity from the standpoint of the compatibility of the implications with accepted knowledge. After revision, these hypotheses are submitted to further test through the collection of data designed to evaluate their validity at the empirical level.

b. Operations Research is problem-centered and systems-oriented and is thus, a technique of using available tools to solve problems. Typically, it views a situation by examining the relationship which exists among a large number of "subsystems" or "components" all of which must function together to solve the problem. It is important that the OR Analyst be able to define the problem--i.e., define, first of all, exactly what he hopes to prove or disprove. Every effort should be made to limit a study to one major question. In no case should the problem to be investigated exceed four major questions.

c. Operations research usually involves interdisciplinary investigations. For this reason, USACDC and USACDCCSG employ people with a variety of backgrounds for use on OR teams or for monitoring and guiding contractual research support. In addition, this approach is followed because of the importance of establishing different views of the same problem.

5. To obtain the greatest value from the material in succeeding chapters of this book, one should keep the following facts in mind:

a. If a problem is to serve its function as a guide in the planning and the conduct of a research study, it must be carefully delineated. A balance must be established between excessive scope, with resulting unmanageability on the one hand, and overrestriction, with its consequent artificiality on the other.

b. Whenever possible, the problem should be converted into an hypothesis to be tested, for hypotheses highlight the direction in which a study is to go, the data that need to be collected in its verification, and the way these are to be processed to provide an adequate answer. Not only does an hypothesis alert the investigator to relevant aspects of the situation and permit him to refine his research design, but it also provides him

with the framework for the interpretation of the findings and the derivation of conclusions. Generally, the formulation of an hypothesis is closely related to the selection and clarification of the problem.

c. The most important criterion of a good hypothesis is its testability. Are its implications, when stated in operational terms, compatible with known facts, and further, are they compatible at the empirical level with the results of research specifically designed to test their validity? An hypothesis is never proved; it is simply sustained or rejected, and, like a theory, an hypothesis may be useful even though it is partially in error. On the other hand, if its significance and scope warrant it, an hypothesis that is sustained may eventually attain the status of law or principle.

d. The research design must be amenable to providing data on the basis of which the problem can be resolved. Inasmuch as no study can be more adequate than the data on which it is based, competence in research requires familiarity with the principles of measurement. Every study must have clearly defined measures of effectiveness. If such measures do not exist, there is no meaningful way to evaluate the results. In addition, the researcher must be familiar with statistical procedures capable of the adequate analysis of the data that have been collected.

e. Among the more common errors in the interpretation of the results of research are failing to see the significance of the data, failing to see the limitations of the research design, overlooking contrary evidence, mistaking coincidence for cause and effect, and reversing the cause and the effect. The best safeguards against such errors are common sense and insight.

6. The techniques discussed in this book are Analytic Modeling, Simulation, Wargaming, Field Experimentation, Troop Testing, Cost-Effectiveness Analysis, Human Factors Analysis, and Systems Analysis. Techniques other than these exist and the number is growing. The employment of operations research to arrive at scientific solutions to problems has become the accepted way of life. As technology advances and as our way of life becomes more complex, new and better scientific techniques can be expected to evolve. An example of such a newly evolving technique is the so-called Delphi technique. Although this technique needs further development and testing, it is regarded by many to be promising. It tries to improve the basic consensus method by subjecting the experts' views to each other's criticism without the psychological shortcomings of actual confrontation (such as specious persuasion, an unwillingness to abandon publicly expressed opinions, and the band-wagon effect of the majority).

The Delphi technique replaces direct debate by a carefully designed program of sequential individual interrogations (best conducted by questionnaires) interspersed with information and opinion feedback derived by computed consensus from the earlier parts of the program. Some of the questions directed to the respondents may, for instance, inquire into the "reasons" for previously expressed opinions; a collection of such reasons may then be presented to each respondent, together with an invitation to reconsider and possibly revise his earlier estimates. From the foregoing, one may conclude that the Delphi technique is a combination of reasoning and systematic problem solving steps. Actually, it is just another emerging technique. It has been discussed to show that new techniques and methods are constantly emerging and on-going. The military OR Analyst must keep himself abreast of the latest trends in techniques and methods. Only by so doing can he meet the evergrowing challenge to provide scientific know-how to the solution of the country's problems in the ever-growing arsenal of technological requirements.

CHAPTER II

GENESIS OF THE USACDCCSG ROLE

1. Background.

Before meaningful effort can take place at the USA Combat Support Group level, there are several important precursory actions that must be carried out at higher levels of Command. The ultimate objective of Army research and development is to develop weapons, equipment, and techniques that are qualitatively superior to those of any potential enemy under all conditions of war. To fulfill this objective, the Army charts its course twenty years into the future, beginning with certain basic guidance documents that provide standardized procedures in the attack on the problem and continuing down through a formalized set of steps and procedures to problem solution. These guidance plans are as follows:

a. The Basic Army Strategic Estimate (BASE) is a long-range estimate of the situation which culminates in the statement of a broad strategic concept and appraisal to meet anticipated threats under all conditions. It considers national objectives and policies, intelligence estimates, and joint planning, and, in the projection of the strategic concept, the technological possibilities.

b. The Army Strategic Plan (ASP) emphasizes the mid-range period (2-10 years). It is directed toward the determination and statement of realistic Army objectives and forces, plus the deployments necessary for execution of the strategic concepts outlined in the BASE.

c. The Army Force Development Plan (AFDP) insures that materiel which results from the R&D program is integrated into existing forces in a manner to best utilize available and oncoming resources. During the development of the plan, R&D personnel provide up-to-date information on the scheduled availability of systems under development and temper development progress in accordance with the schedules for the fielding of such systems.

d. The Long Range Technological Forecast (LRTF) presents knowledge, capabilities, and examples of materiel which science and technology could be expected to produce over specified time periods out to twenty years when supported by orderly programs of research and development.

e. The Army Research Plan guides research and exploratory development and is the vehicle for planning courses of action leading to advances in the scientific and technological base. It must support the desired operational capabilities which are derived from the Army Concept Program (see below).

f. Concept Program. Here, for the first time in the program, USA Combat Developments Command (CDC) assumes a major role in the R&D planning system. CDC has the mission to formulate current doctrine for the Army in the field, to determine the type of forces and materiel needed in the future, and to determine how these forces and materiel should be employed. To accomplish this mission, CDC develops a series of programs. Each program includes a concept study, a statement of the probable threat, supporting doctrinal studies, and all derivative combat development actions necessary for modeling the Army of the future for a specific five-year period. When the program becomes fully operational, concepts will have been prepared and approved for each five years extending twenty years into the future. Studies are identified by the final implementation year; i.e., Army-70 is the study identifying the Army in the Field in the 1965-70 time period.[1]

The Doctrinal Studies, approved fifteen years prior to implementation, provide the link between broad guidance included in the concept study and the detailed methods of operation developed by follow-on derivative studies. Doctrinal studies cover the combat, combat support, and combat service support aspects of Army operations at the Division, Corps, and field Army level.

Basic Derivative Studies, approved ten years prior to implementation, provide an expansion of the doctrinal studies and are branch or functionally oriented. As will be discussed later, the USACDC Combat Support Group performs a key role in derivative studies pertaining to combat support functions. In addition to developing small unit operations (brigade and lower), the derivative studies provide requirements for specific organizations and are the basis for tables of organization and equipment and doctrinal field manuals.

2. The Five-Phases of the Program. USACDC employs five distinct phases in the systematic and scientific solution of combat development problems. They are as follows:

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[1]Army-85 (75-85) Doctrinal Study. On 19 January 1968, the CDC CG directed that a letter be sent to DA informing them that our next development program (which embodies doctrinal study subsequent to

a. Phase I - Preparation of the Concept Study. This, of course, is the beginning phase. Here, the Concept Study is formulated to determine the problems that exist, tasks involved in overcoming them, and goals to be achieved. The following steps are important in the preparation of the Concept Study:

(1) Based on National and Allied policy, all available intelligence, scientific and technological forecasts and the threat, USACDCIAS (Institute of Advanced Studies) prepares broad guidelines for alternative operational concepts which include precepts, outlines, and other appropriate aspects for the five-year program period.

(2) Based on this guideline, the Institute of Advanced Studies calls upon pertinent institutes and agencies of the USACDC to provide them with branch and functional input. In developing this input, institutes and agencies conduct an analysis of the time period under consideration, including proposed concepts, materiel requirements, and organizations envisioned.

(3) By means of a creative, selective, and verification process, a concept study is finalized and submitted to DA for approval. When approved by DA, the concept determined the direction of Combat developments for the Army Concept Program. All USACDC institutes, groups, and agencies will be kept informed by IAS in regard to the development of the alternative operational concepts via liaison visits, conferences, and in-process reviews. The concept also provides a basis for development of Operational Capability Objectives (DA-approved description of operational capability, the achievement of which is desirable in the long-range time frame).

b. Phase II - Preparation of the Doctrine Study, QMDO and QMR. Based on the approved concept study, the Institute of Combined Arms and Support (ICAS) prepares the Doctrine Study. This study involves the development of the Combat, Combat Support, and Combat Service Support doctrine for the Army in the field. The Doctrine Study, developed in considerable detail, extends to the lower command levels. In this study, ICAS uses the acceptable branch or functional concepts developed by the agencies as input

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CAAS-75) will be "the Army-85 (75-85) Concept Program". Implied in this decision is the concept that no Army-80 Concept Program will be particularly addressed as such. This decision in no way suggests that the CDC 5-year development cycle has been abrogated, but in fact, the intent of this decision is to assist in overcoming the dampening effect of closely programmed actions by combining the

to the "Concept Study" as relevant data for the "Doctrine Study". The Doctrine Study serves as a synthesizing influence for the separate branch-oriented concepts developed by the agencies, thus providing the approved doctrine study a basis upon which the agencies can develop their basic derivative studies. Materiel objectives and requirements identified during preparation of the doctrine study are developed as QMDO or QMR as appropriate.

c. Phase III - Preparation of Basic Derivative Studies. During phase III, a series of basic derivative studies is made to determine the doctrine, organization, and materiel necessary to support the new concept. Requirements for evaluation or follow-on actions, for Field Manuals, and for submission or review of Qualitative Materiel Requirements (QMR) and Small Development Requirements (SDR) are identified.

d. Phase IV - Preparation of Field Manuals and Tables of Organization and Equipment. During this phase the approved needs in personnel, materiel and organization identified by the basic derivative study are implemented. The Agency prepares for approval, new or revised field manuals and TOE, containing approved doctrine for integration into the Army in the field.

e. Phase V - Evaluation. During this phase, the entire plan is tested for validity after which, the approved doctrine, materiel, and organizations are integrated into the Army in the field. It must be remembered, however that evaluation cannot be confined strictly to Phase V. It is true that Phase V, itself, deals almost completely with the evaluation process, but evaluation of some sort must take place in each of the other phases. The concept, the doctrine, the organization, the procedures used, and the policies followed must all be carefully evaluated at the beginning, while in process, and at the end. The use of operations research techniques for empirical solutions to problems implies a constant and on-going evaluation and analysis from beginning to end - from concept to implementation.

3. Definitions. The following definitions are important to an understanding of operations research methodology as employed within Department of the Army.

75-85 time frame doctrinal developments requirement in a one-time catch-up Army 80-85 doctrinal study effort. This doctrinal study should include sufficient doctrinal transitional links cognizant of those major materiel developments to be fielded in the post-75 time frame which may impact dramatically upon doctrinal and organizational precepts embodied in the antecedent doctrine. In this context, Concept-85 and Concept-85 Expansion will be the

a. Qualitative Materiel Development Objective (QMDO). The statement of an existing need for a certain kind of equipment, materiel, or system wherein the feasibility of successful development is not known. Research and/or exploratory development are still necessary.

b. Qualitative Materiel Approach (QMA). The forwarding by AMC to USACDC of one or more technically feasible solutions that may evolve from R&D based on the QMDO that can be developed in a specific time period if adequate resources are made available. Upon receipt of the QMA, a QMR is normally the next immediate step.

c. Qualitative Materiel Requirement (QMR). The QMR differs from the QMDO in that the technical and scientific feasibility of developing the items or systems is known. The QMR is more specific in its definition and description of what is required. The QMR guides engineering development of an item for service use.

d. Small Development Requirement (SDR). An approved statement of a Department of the Army need for an item of equipment of low cost and simplicity which can be developed in a relatively short time and does not warrant the major effort required in developing a QMR.

e. In-Process-Review (IPR). A review of a development project conducted at critical points of the development cycle to evaluate the status of the project, accomplish effective coordination and facilitate proper and timely decisions bearing on the future course of the project.

f. Disciplined Challenge to Qualitative Materiel Requirement (DCQMR). A formal evaluation, conducted subsequent to the approval of a QMR and prior to type classification, which considers concurrently all aspects bearing on the QMR, to revalidate, amend or eliminate the QMR. It is an additional formal analysis conducted subsequent to the approval of a QMR and prior to type classification on selected high priority and high dollar value QMR to determine if, with passage of time, the QMR is still valid.

g. Essential Elements of Analysis (EEA). A series of specific questions designed to direct the analytical process in a study so as to provide comprehensive, complete, reliable, and useful findings which in the aggregate will accomplish the purpose of the study. EEA should indicate the scope of the analysis to be

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conceptual foundation upon which the doctrinal effort will be based.

performed, normally by being worded so as to require a definitive, not a "yes" or "no", answer.

h. Study Methodology. The analytical techniques used in a combat development study. A detailed outline showing the step-by-step development of the solution of a problem. It will include the employment of Operations Research or other techniques as appropriate, will identify the rationale for analysis and the proposed method for synthesis by which input data are to be manipulated, and will designate the criteria to be used to reach the findings and/or conclusions.

i. Basic Derivative Study. A combat development study which provides an expansion of the information contained in the doctrine study. It is oriented toward a comprehensive study of one of the branches or functional areas of the Army in the field and is normally prepared in support of each doctrine study. As such, the Basic Derivative Study (BDS) is guided by, but not limited by the doctrine study and is normally initiated prior to completion of the doctrine study. The BDS is prepared in sufficient depth and detail to permit the subsequent writing of doctrinal literature, tables of organization and equipment, and materiel requirements. Those combat development studies which consider specific subjects not examined in the doctrine study or analyze a subject in even greater detail or for a time frame not compatible with consideration as part of a basic derivative study are identified as "Other Derivative Studies" and as "Special Studies".

j. User Guidance. The monitoring (as the representative of the user) of the development of a specific item of equipment or system which is normally based on a DA-approved QMDO, QMR, or SDR. It includes all the effort required, as representative of the user from the time research and development is initiated through to the initial issue of the item and includes the period after the item is issued to the troops.

CHAPTER III

CSG ORGANIZATION

1. General. Headquarters, USACDC Combat Support Group and its assigned branch agencies are major producing organizations for derivative studies, branch-oriented field manuals, proposed statements of materiel objectives and requirements, tables of organization and equipment, proposed statements of MOS requirements, and TOE manpower authorization criteria studies. The Combat Support Group is charged with ensuring that its assigned agencies develop and coordinate the doctrine, materiel requirements, organizations, and evaluation requirements for brigade and lower levels. To facilitate the accomplishment of its mission, USACDC Combat Support Group is organized into the following five divisions: Administrative, Programs and Budget, Concepts and Doctrine, Materiel, and Organization and Evaluation. With the exception of the Administrative Division, each of the remaining four will participate in the staffing when operations research is being employed to solve problems within the USACDCCSG mission. Briefly, the chief functions of each of the four operational divisions are outlined in succeeding paragraphs.

2. Programs and Budget Division. Compiles, coordinates, and monitors execution of the USACDC Combat Support Group combat developments program. This Division keeps the Commanding Officer informed on the status and progress of the Group program and of individual projects, changes in priorities and schedules, the impact of new projects, and gaps or duplications in the program. The Programs and Budget Division provides guidance to Group Headquarters and subordinate agencies for the development, submission, and review of funding requirements; coordinates and monitors the funds for contractual research support management; maintains an up-to-date accounting of expenditures, obligations, and funding requirements; implements DA and USACDC accounting and financial management regulations and directives; and monitors host installation implementation of DA guidance as it may pertain to USACDCCSG.

3. Concepts and Doctrine Division. Examines all conceptual and doctrinal drafts and publications submitted to the Group to ensure correlation with the appropriate Army concept program and to ensure that all intensities of conflict are addressed under the appropriate or postulated threat analyses. Through close coordination with assigned agencies, it ensures that combat developments products of the agencies meet the conceptual and doctrinal objectives and requirements in each Army concept program. This Division is the point of contact between USACDC Combat Support

Group and other groups and commands in regard to conceptual and doctrinal studies. The Concepts and Doctrine Division is the focal point of the Combat Support Group in all matters pertaining to concept and doctrine. To ensure conformity in these areas, the division analyzes basic derivative studies and field manuals prepared by the agencies; reviews conceptual and doctrinal studies or manuals which are USACDC proponency other than USACDC Combat Support Group; manages the development of basic derivative studies by assigned agencies; supervises, reviews, and evaluates the development of doctrine by subordinate agencies, as reflected in the field manuals for which those agencies have proponency; and coordinates closely with Materiel Division in matters relating to material and with Organization and Evaluation Division in matters pertaining to Organization and to the proper means of employing operations research to solve USACDCCSG problems.

4. Materiel Division. Supervises and coordinates combat support derivative actions in the Materiel Phases of each Army concept program. It insures that the combat development materiel requirements products developed by subordinate agencies meet the objectives and requirements stated in the doctrine study for each Army concept program. It ensures that user guidance is provided research and development activities for the purpose of making certain that materiel developments meet objectives or requirements specified in QMDO's, ADO's, QMR's, SDR's and similar documents. It supervises, evaluates, and correlates the flow of materiel input from subordinate agencies to the USACDC developmental institutes and other USACDC agencies. Materiel Division also recommends additions to, deletion from, or modification to combat support items of equipment and munitions of the supply system.

5. Organization and Evaluation Division. Reviews and analyzes organizational and evaluation combat developments actions and coordinates these actions with subordinate agencies, other groups, and appropriate staff directorates of Headquarters, USACDC. Participates in doctrine, materiel and organization studies and formulates, recommends, or approves operations research methodology for scientific solutions to problems in all three areas. This Division reviews, for control and content, tables of distribution and allowances and supervises and coordinates the development of the Group's portion of the organizational program. The Organization and Evaluation Division also reviews agency field experiment requirements and plans ensuring that the objectives are compatible with the evaluation of prescribed combat support aspects of doctrine, materiel, operational, organizational and logistical concepts.

CHAPTER IV

COMBAT DEVELOPMENT STUDIES

1. Definition and Classification. The principal reason for the existence of the Combat Support Group is to contribute to, develop, or complete studies that will lead to qualitative superiority of our men, weapons and equipment. As defined in USACDC Regulation 71-3, a combat development study is a formal analysis to determine new or improved operational concepts and doctrine, materiel requirements, and organizational structure for the Army. Combat development studies may be classified as follows:

a. Concept Study. A combat development study directed toward guiding the development of a unifying concept for the Army missions in the strategic/tactical environment forecast for the period. The concept study is prepared as a basic step in an Army concept program. It analyzes the threat, environment, technology, and strategic concepts contained in the Basic Army Strategic Estimate, the Army Strategic Plan, and related studies. The concept study addresses the entire range of Army tasks, including those of the Army in the field, and examines joint and combined operations with other services and allied forces. It is approved by both Headquarters, USACDC and Headquarters, DA. As such, a concept study, per se, is never formulated at Group or agency level: Groups and Agencies contribute input as necessary, but the study is formulated and completed by IAS. Headquarters, USACDC initiates the development of the concept study by issuing a study directive. IAS then prepares a guideline for the study, including precepts, outline, and other appropriate aspects. Early in its preparation, IAS may, if necessary, require input from USACDC Groups and agencies. In order to provide this input, the Group and subordinate agency will conduct an analysis of the time period under consideration, including proposed doctrine, materiel requirements, and organization. Groups and agencies will be kept abreast of the development of the concept study through liaison visits, conferences, in-process reviews, and other appropriate means. Agencies will submit their input through CSG to IAS, where differences or incompatibilities in the separate submissions will be resolved.

b. Doctrine Study. A combat development study which provides, for a designated time period, a detailed treatment of the broad concepts developed in the concept study. In addition to a general consideration of operational doctrine for the Army in the

field, the study addresses combat, combat support, and Combat Service Support doctrine at the field Army, Corps, and division levels and combat support doctrine at the field army, Corps, division, and brigade levels. It is prepared by the USACDC Institute of Combined Arms and Support and approved by HQ, CDC and HQ, DA; it may be initiated prior to completion of the supported concept study. The doctrine study describes pertinent conflict environments, develops scenarios, and evaluates type tactical and supporting force models against plausable enemy threats. In the early stages of the doctrine study, the Combat Support Group will require input from agencies and guidance from the concept study.

c. Derivative Study. A combat development study which provides an expansion of the information contained in the doctrine study for a designated time period or which considers specific subjects not examined in the doctrine study. These studies are of two kinds, basic derivative studies and other derivative studies. Basic derivative studies are oriented toward a comprehensive study of one of the branches or functional areas of the Army in the field;such studies are normally prepared in support of each doctrine study. As such, they are guided by, but not limited by, the doctrine study and are normally initiated prior to completion of the doctrine study. They are prepared in sufficient depth and detail to permit the subsequent writing of doctrinal literature, tables of organization and equipment and materiel requirements. Groups and Agencies perform "other" derivative studies to analyze a specific subject in even greater detail than a basic derivative study or in a manner or for a time frame not compatible with consideration as a part of a basic derivative or other study.

d. Special Study. A combat development study requirement directed by Headquarters, Department of Army and which cannot be satisfied by a programmed concept, doctrine, or derivative study. Upon completion, it is approved or disapproved by Department of the Army.

2. Sources of Studies.

a. General. Combat development studies, elements of the USACDC program, are described in detail in Volume I, USACDC Pamphlet 71-3. The USACDC program is composed of four separate Army concept programs[2], each of which addresses a specific 5-year

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[2] It consisted of five programs until 19 January 1968 when the CG, USACDC directed that the Army-80 and Army-85 concept studies be combined.

implementation period. The first phase in development of each of these Army concept programs includes the preparation of a concept study, which is directed by HQ, USACDC, and approved by DA. This phase also includes a threat study, which is used to provide study agencies with a forecast of the conflict environment and enemy threat for the pertinent time period. While the concept study is in preparation, providing an approved and valid threat projection is available, the doctrine study may be initiated, based on the conceptual guidance furnished in the concept study and doctrine study directive. The doctrine study, directed by the CG, USACDC, is forwarded to DA for final approval. Approval by the CG, USACDC of a concept or doctrine study constitutes authority to use the study contents as approved guidance within USACDC. Concept studies, then, are never formulated or accomplished at Group level. HQ, CDC and CDCIAS (Institute of Advanced Studies) generally call upon CDC Groups and Agencies for specifically required input into the Concept Study, but the Concept study, per se, is accomplished by CDCICAS (Institute of Combined Arms and Support). The doctrine study provides the link between the Concept Study and the detailed method of operation arrived at by derivative studies. In other words, the approved doctrine study constitutes approved guidance for all derivative studies, the results of which must sooner or later be fed back into the doctrine and concept studies to make them complete for the time frame for the Army Program Concept that they represent. It may be seen then, that the chief study with which the USA Combat Support Group is involved is the Basic Derivative Study; that the Combat Support Group is functionally concerned with making basic derivative studies to determine ways and means of implementing the concept and doctrine at brigade and lower levels of command. All Group studies are prepared by direction or approval of the CG, USACDC (unless the CG USACDC has granted approval authority to a Group agency). In the case of basic derivative studies, the approval authority is normally delegated to Group Headquarters. They are not necessarily forwarded to HQ, USACDC for approval unless expressly directed by the study directive or other instructions. The following specific principles apply to all derivative studies.

(1) Basic derivative studies must be in consonance with Army plans and with the USACDC concept of operations. They will be prepared as phased efforts in accordance with the Critical Date Analysis Guide in Volume I of USACDC Pamphlet 71-3.[3]

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[3] The critical Date Analysis Guide has been deleted from Volume I, USACDC Pamphlet 71-3, but a forthcoming letter from HQ, USACDC will give milestone dates for CDC Basic Derivative Studies. CDC will publish a new critical Date Analysis Guide sometime during early FY 69.

(2) Studies will normally be approved by the Headquarters which established the requirement for the study and/or issued the study directive.

(3) Derivative studies directed by group Headquarters but having cost analysis or trade-off implications will be coordinated with Headquarters, USACDC to determine whether that Headquarters desires to assume approval authority.

(4) Studies with foreign policy impact will be coordinated with HQ, CDC to obtain clearance from the appropriate DA general staff agency before the study is initiated or as soon as the implication is identified.

(5) Foreign Intelligence data used in the preparation of studies will reflect the most recent information available and will be based on intelligence approved by the DA Assistant Chief of Staff for Intelligence, Defense Intelligence Agency, and the USACDC Plans Directorate. Target arrays, if required, may be selected from those considered most appropriate and as listed in USACDC Pamphlet 381-1, Foreign Intelligence Reference Guide. They may be modified or updated as necessary, but any modification or updating of target arrays or threats must be approved by HQ, CDC.

(6) Studies which cannot be performed within the capabilities and resources of the proponent agency may be recommended for execution or support by contractual assistance in accordance with USACDC Regulation 71-6. Another source of assistance from outside resources is the unfunded study program (see AR 70-35, Unfunded Study Program).

(7) Early in the study, consideration must be given to the degree of participation by other Army commands, particularly the Army Materiel Command, and other services and governmental agencies in order to insure sufficient lead time in the development of the study.

3. Initiation of Studies. Combat Development Studies may be initiated in any one of the following ways:

a. By directive or request from higher headquarters. As soon as a study need is recognized as being a requirement in support of the USACDC program, the Commanding General, USACDC issues a study directive. The directive sets forth the parameters, that is, the purpose of, objectives, scope, basic facts and assumptions, and necessary detailed guidance for specific problem areas and appropriate time frames. The directive contains a statement of the purpose and the tasks to be performed; specifically, what is to be accomplished and for what reason or use. (To insure the

maximum degree of professional competence in the study area, Headquarters, USACDC may require the proponent element to prepare a draft study directive. In such case, the proponent agency will prepare the draft in accordance with procedures outlined in APPENDIX 1, USACDC Regulation 71-3 and submit it to the directing headquarters for approval.) The study may be in the nature of input to concept studies being conducted by IAS or Doctrine studies being conducted by ICAS.

b. By identification of need at Agency or Group level. Frequently, a Group or proponent agency will analyze a study directive and ascertain the existence of various sub-problems that must be solved in conjunction with, or prior to the beginning of the principal derivative study. When such a need is determined, the proponent agency may refer the initial directive back to the directing headquarters with recommendation for amendment to the original study directive, or it may submit a USACDC Form 87 to request authorization for a separate study.

c. By request from other agencies. Another agency having proponence may need information in order to develop their study. In such cases, that agency may request the agency or group most technically competent in the particular area to perform the study or provide inputs to a study.

d. By request from Army Materiel Command or other major commands. Frequently, study needs will develop as a part of larger studies being carried out by AMC or other commands. Such needs may be in the area of technical competence of a CDC agency or organization, or in some cases, it may be advantageous for CDC and the other command to collaborate, confer, or work jointly on a derivative project. In such cases, the project must be approved by the CG, USACDC.

e. By request from USCONARC school. Each USCONARC school has Combat Development representatives. Because of the intimate contact existing between USCONARC schools and the Army in the field, valuable sources of information may appear early at the school. Analysis of such information will frequently reveal the need for a study in a particular area. In such instances, the school makes the requirement known to CDC, the need is tied in with a concept program, and HQ, CDC issues, or causes to be issued, a study directive.

f. By solicited and unsolicited recommendation from civilian industry. One of the primary missions of USACDC is to avail itself of advances in technology which will increase the effectiveness of the defense establishment. To do so, it is imperative that advances in civilian as well as military technology be observed and, where practical, adopted. Frequently, USACDC

will call upon industry for studies which, in the process of completion, will generate requirements for other studies. When a valid recommendation from industry is received, USACDC will issue a study directive.

g. Other means by which studies are initiated will often stem from requirements of the Air Force, Navy, or Marine Corps; and from international organizations such as NATO and ABCA.

h. By In-Process Reviews. An important step in the evolution of any study -- a step frequently leading to other studies-- is the In-Process Review (IPR). The IPR is the evaluation of what has been accomplished, what is to be accomplished, and the relationship of both of these to the overall objective. Such evaluations may be in the form of formal IPR's or may be an assessment by an individual officer to insure that his efforts are being directed toward accomplishment of the desired objective. When an additional study requirement is generated as a result of an IPR, the proponent agency should prepare a USACDC Form 87 and submit it to Headquarters, USACDC.

i. By Project Advisory Group recommendation. When studies or special projects are performed by contract for CSG or subordinate agencies, HQ, CSG will publish special orders appointing a project advisory group (PAG) to guide, direct, and monitor the contract study. The PAG will submit to CSG, through the proponent agency, requests for modifications, changes, extensions, or termination of any contract for scientific support as soon as the need therefor becomes apparent. A PAG would recommend further or new studies for requirements generated in the course of the contracted study but not provided for by the original contract.

CHAPTER V

OPERATIONS RESEARCH METHODOLOGY

1. General. Before the reading of this pamphlet is continued, a review of Part 1, Methodology Notebook for Action, United States Army Combat Developments Command, May 1967, should be made. Part 1 provides basic guidance in and information on the background and characteristics of operations research, its phases, the Army Function-Phase-Mission Matrix, and a brief insight into the available operations research techniques.

2. The Scientific Approach. The primary reason for the existence of USACDC is to determine how the Army shall fight, how it shall be equipped, and how it shall be organized. An accurate determination in these areas is possible only through scientific analysis, or employment of the scientific approach and its continuance to an empirical solution. The scientific approach consists of the formulation of hypothesis and testing them by controlled experiments and trials, with the aim of guiding the decision maker in the selection of a solution. The analysis that follows must be based upon a logical, sequential approach. Observations and statements about the situation must be subjected to inquiry regardless of how obviously true they may appear on the surface. This must be done in such a manner that the problem assumes a precise and irrefutable aspect through a concise description.

3. Problem Identification and Definition. Studies are forwarded to the Combat Support Group and to its related agencies for solutions to problems. In many cases, the problems will be completely identified upon arrival. In other cases, often in the matter of concept and doctrine, it will be necessary for the group or agency to define the problem. Thus a process of evaluation must begin immediately. Here, evaluation must take place at the beginning of the study as well as at the end. This is so because early determination must be made as to the definition of the problem, its isolation from other problems, the scientific investigative technique that is most appropriate, and the identification of measurement data that are to evolve at the end of the study. Once a problem has been identified and the decision is made to solve it, the process of evaluation is continuous, from evaluating the essential elements of analysis and the various items of input data until the evaluation of the doctrine being applied by the Army in the field or the item of materiel in the hands of the user.

4. Knowledge Gaps. Basically, the attack on a problem is occasioned by a coordinated effort on the part of Administrative Division, Concepts and Doctrine Division, Organization and Evaluation Division, and Materiel Division. A particular study may be initially received by Administrative Division and forwarded to the other division in whose specialty area the study lies. If the study is one that requires mere assembly of existing data or the accomplishment of library-type research, it may be executed and completed within the confines of the proponent division and the relevant agency or vice-versa. Most studies, however, will require some form of empirical solution, or they will contain a knowledge gap which must be closed by scientific analysis and research into the problem area. When a knowledge gap is identified, there arises a requirement for initial evaluation. Staffing agencies must remain on the alert for early recognition of these knowledge gaps so as to insure that a study is not begun without steps having been taken that will lead to early evaluation of the problems and to the scientific and economical approach to their resolution. It is a common staffing error to think of evaluation only in terms of the fifth or final phase of a study. This error may result in much work being done before it is discovered that essential areas of study have not been clearly identified or that much of the effort has been wasted. When such gaps are discovered, they should be forwarded immediately to the Organization and Evaluation Division where operations research techniques will be employed in the attack on the problem areas (see Figure 1). Some projects, by their nature, are knowledge gaps. An example of this point would be an effectiveness study to determine which of several alternate approaches is the most effective. The staffing direction in such a case is fairly obvious. The most effective of several alternate approaches generally can be determined only through scientific analysis. Such a study should be referred to the Organization and Evaluation Division.

5. Factors Requiring OR Determination. Upon receipt of a problem, Organization and Evaluation Division will analyze it for determination of the following factors.

a. Method to be Employed. Not only must the research analyst prescribe the EEA, select a meaningful and economically attainable objective, name the parameters, and develop criteria, but he must also develop a group of alternatives which are representative yet not exhaustingly excessive in number--economical yet effective. With the relevant data at hand, he is then ready to determine the model that is most appropriate and, hence, the one that will signal the research technique that is to be employed. He may select any one or any combination of the following:

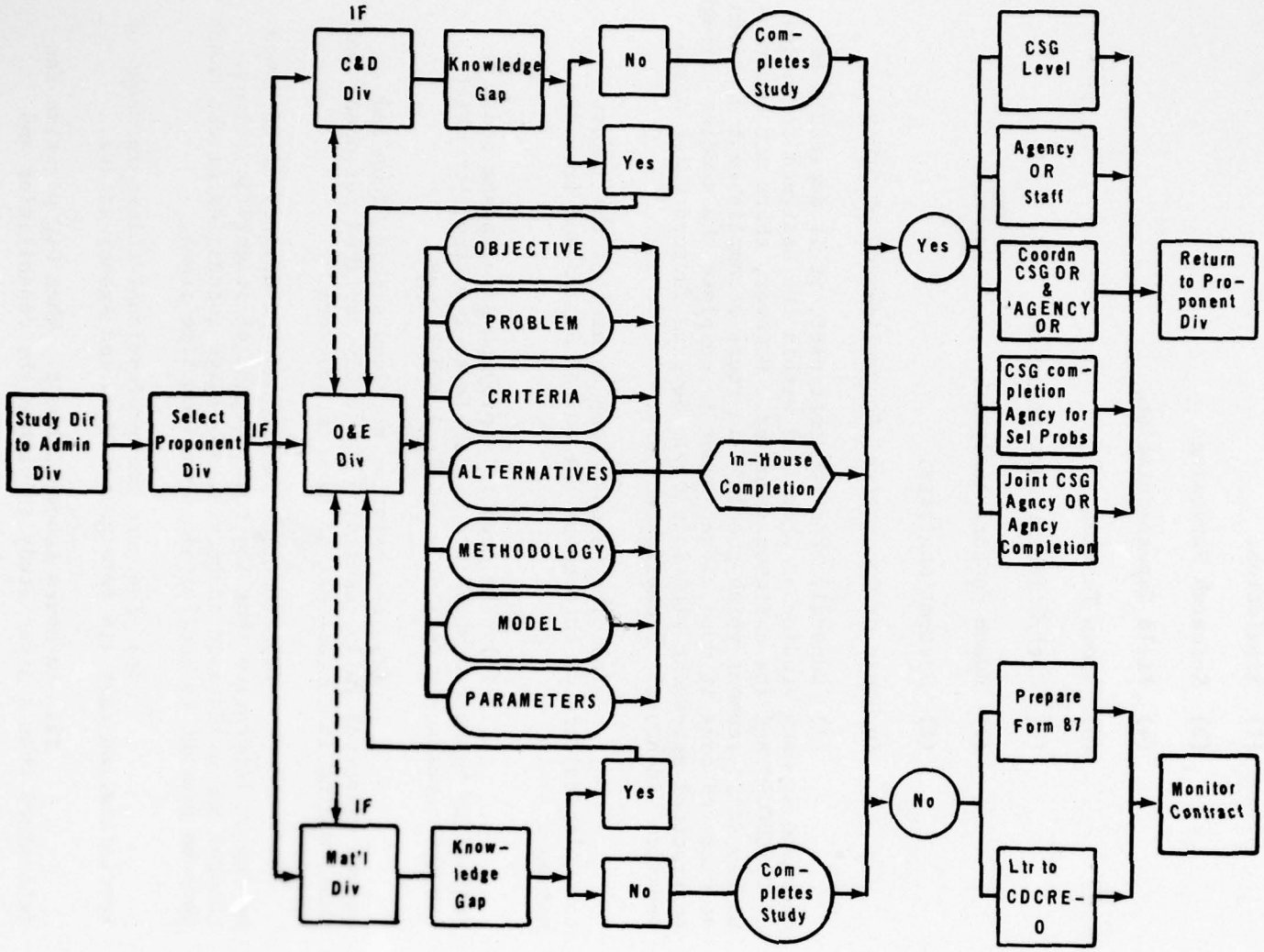

Study Dir to Admin Div
Select Proponent Div
IF
O&E Div
IF
C&D Div
Knowledge Gap
No
Yes
Com-pletes Study
OBJECTIVE
PROBLEM
CRITERIA
ALTERNATIVES
METHODOLOGY
MODEL
PARAMETERS
in-House Completion
IF
Mat'l Div
Know-ledge Gap
Yes
No
Com-pletes Study
Yes
No
CSG Level
Agency OR Staff
Coordn CSG OR & AGENCY OR
CSG com-pletion Agncy for Sel Probs
Joint CSG Agncy OR Agncy Completion
Return to Pro-ponent Div
Prepare Form 87
Ltr to CDCRE-O
Monitor Contract

Fig 1

(1) Analytic Modeling.

(2) Simulation.

(3) Research Wargaming.

(4) Field Experimentation.

(5) Troop Testing.

(6) Cost/Effectiveness Analysis.

(7) Human Factors Analysis.

(8) Systems Analysis.

b. In-House or Contractual Accomplishment of Study.

(1) General. For the most part, it is desirable to complete as many studies as practical within the assigned resources of USACDCCSG and its assigned agencies. However, there are numerous highly valid reasons which preclude in-house accomplishment of given studies and make it more advantageous to complete the studies through contractual agreement with industry. Several factors which often preclude "in-house" accomplishment are:

(a) The need to keep abreast of the latest technological trends throughout the United States and friendly nations.

(b) The need to employ physical plant and scientific resources which are available to industry, but which are not necessarily available to the Armed Forces.

(c) The existing workload within Group and Agency resources fully committing presently assigned personnel and, thus, making it impractical to take on new work.

(d) The time factor and the urgency of the need making it imperative that the total weight of scientific talent, natural and scientific resources, and large quantities of man month work be brought to bear within a minimum time frame.

(e) The need for professional talent in areas of specialization that are foreign to Group and Agency assets.

(2) In-House Accomplishment. When O&E Division has determined that a given study is within the capabilities and

resources of the Group or its assigned agencies, the CO, CSG may direct that the study be completed in any one of the following ways:

(a) It may be completed at Group level.

(b) It may be completed by operations research personnel at agency level.

(c) It may be analyzed partially or completely by CSG operations research personnel and then forwarded with prescribed operations research methodology to the agency.

(d) It may be partially completed by CSG operations research personnel and then forwarded to the agency for solution to selected problems and return to Headquarters, CSG for completion.

(e) It may be jointly analyzed and research methodology defined through coordinative effort between CSG OR personnel and agency OR personnel with the agency completing the study.

c. Types of Contractual Scientific Support. Procurement of scientific support by means of a contract is justified only if there is a necessity for the use of scientific skills, techniques, and capabilities not otherwise available to the Army. It may properly be used for the following purposes:

(1) To provide an end product which furnishes a scientific basis for a necessary decision.

(2) To provide operations research support in the form of systems analysis, cost effectiveness analysis, simulation, wargaming, and human factors analysis.

(3) To develop techniques and methods for the conduct, control, and evaluation of wargaming, field experimentation, and troop testing.

(4) To develop techniques and methods for the accumulation, processing, and analysis of relevant data in accordance with accepted scientific principles in order to insure that conclusions reached are valid and scientifically supported.

CHAPTER VI

CONTRACTUAL RESEARCH SUPPORT MANAGEMENT

1. Responsibilities of CSG. Once the decision has been made (either at Agency or Headquarters, CSG level) to obtain contractual scientific support, the following actions are incumbent upon Headquarters, CSG:

a. Determining the requirements for contractual scientific support at the earliest possible time, both for Headquarters, CSG and assigned agencies, and submitting appropriate requests to Headquarters, CDC.

b. Disapproving requests for contractual scientific support from subordinate agencies when such requests do not satisfy CDC criteria. However, if a request pertains to a directed special project, a summary of the request and the reasons for its disapproval must be forwarded to CDC.

c. Coordinating and monitoring all contracts and requests for scientific support for itself and any subordinate agency in order to insure that:

(1) There is no duplication of effort or overlapping of projects.

(2) Wherever practical, all tasks falling within the scope of a project assigned to a particular contractor are performed by that contractor, even though it may be necessary to request amendment to the contract or to extend the period of performance.

d. Advising CDC of any new scientific development, state-of-the-art advance, or technological breakthrough resulting from the performance of a particular contractor.

e. Insuring that required reports and reviews and evaluations of contractor performance are accomplished and submitted at the proper time.

f. Submitting to Headquarters, CDC, requests for modifications, changes, extensions, or terminations of any contract for scientific support as soon as the need therefor becomes apparent.

g. Making available a project officer or a qualified contracting officer's representative when requested to do so.

2. Procedures for Submitting Contractual Requests.

a. The element of the Command which first identifies a requirement for scientific contractual support will prepare a USACDC Form 87 (Action Control Record) to identify the new action. This Form 87 will be processed in accordance with Vol 1, USACDC Pamphlet 71-3, April 1968.

b. The request for contractual scientific support will be made in the form of a letter addressed through channels to HQ, USACDC, ATTN: CDCRE-O. This letter will include as an inclosure, a copy of the Form 87 and subject to the exceptions stated in "c" below, contain the following information:

(1) Objectives. Concrete statements as to exactly what the action will be designed to accomplish.

(2) Nature and Scope. A description of the problem and its limits and the specific areas of investigation which will be explored during the conduct of the action.

(3) Need for the Action. A clear statement of existing problems or undesirable practices, conditions, or situations which generated the requirement for this proposal, and the degree of urgency involved, with reasons, or title and date of action directive.

(4) Assumptions or other guidance which will control the action.

(5) Results Anticipated. Clear statements of the specific results which can reasonably be expected from the required action; the specific end product if one is required, such as a new or revised manual; qualitative improvements the action recommendations are expected to achieve; estimates of expected economies in terms of money, man-hours, personnel, material, and units of production.

(6) Impact of Disapproval. A statement of the actual or estimated effect on the mission of the Group or agency should the requested action fail to receive approval.

(7) Skills. Requisite skills to be utilized and evaluation of the skills available within the sponsoring headquarters or assigned agency to show whether there is a lack of in-house expertise to accomplish the work.

(8) An estimate of the cost.

(9) Estimated period of performance.

(10) Estimates of level of effort in terms of man-months or years in particular occupational categories.

(11) Desired commencement date.

(12) Recommendations concerning contractor, if appropriate.

c. Where the request for contractual scientific support must be submitted before all the information required in "b" above is available, the request should so indicate, and the missing information should then be furnished at the earliest practicable time.

3. Relations with Contractors. AR 600-50 prescribes standards for and places restrictions upon personnel with regard to procurement and related activities. Provisions of AR 600-50 must be strictly followed. In addition, all personnel will observe the following:

a. A contractor will not be requested either formally or informally to submit a proposal or quotation without prior approval of Headquarters, USACDC.

b. Presolicitation conferences or so-called bidders conferences will not be held without prior approval of HQ, USACDC.

c. Prospective contractors will not be furnished information or guidance in addition to that given them in synopses, invitations for bids, requests for quotations, or in authorized conferences of the type described in 3b above, without the specific approval of Headquarters, CDC in each case.

4. Monitorship of Contracts. The Commander of the USACDC element which receives scientific contractual support is responsible for monitoring the performance to insure that the contractor's progress and end product are consistent with the projects and tasks assigned. He will also be responsible for making a recommendation to the contracting officer concerning acceptability of the work from a technical standpoint. The Commander may designate a member of his command as a project officer to perform this function or he may perform it himself. In either case, the project officer will be responsible for keeping the contracting officer informed. The project officer and the contracting officer's representative (frequently they will be the same officer) are the Army's chief

means of providing monitorship of contractual scientific support on a day-to-day basis. For longer periods and for more thorough review and evaluation, CSG will appoint a Project Advisory Group. If a study pertains to a materiel development project, it may also be evaluated by an "In-Process-Review".

a. Project Advisory Group (PAG). As a minimum, each scientific or operations research support contract for which USACDCCSG has responsibility will require the formation of a PAG. Policies and procedures relative to the establishment, composition, and functions of PAG's are defined in USACDC Regulation 71-16, 27 July 1967, and USACDCCSG Regulation 71-4, 11 March 1968. Each PAG is charged with the mission of providing overall monitorship of contract studies for which they are responsible and managerial liaison between the proponent commander and the contractor(s) providing the scientific support. The objective is to insure that this support is developed under the proper terms of reference and that it responds to contract directives. PAG's will provide advice to the proponent commander and respond to his direction in all matters pertaining to performance of the contract for which the Commander has the ultimate responsibility. To insure high quality implementation of the CSG and CDC PAG regulations, each proponent agency commander should evaluate PAG membership and operational procedures for determining conformity with regulations and identifying areas that will enhance PAG employment. Items not necessarily listed in the regulations that may promote PAG efficiency are as follows:

(1) Scheduling of Meetings. PAG meetings must occur not less frequently than quarterly; however, there are numerous instances when great advantages can be derived if the PAG meets more often. When full PAG meetings are impractical for valid reasons, the chairman is authorized to convene a few members for disposing of matters deemed necessary. It is, in many cases, preferable that matters be considered by a few members rather than be postponed until the next quarterly meeting.

(2) PAG Membership. CDC Regulation 71-16 and CSG Regulation 71-4 specify the minimum composition of a PAG. Each regulation provides considerable flexibility for contingencies. The important point for agency commander consideration is PAG nominee qualifications. All PAG members should possess a majority of the following characteristics:

(a) Vital interest in the project.

(b) Knowledge, talent, or experience in the subject area.

(c) Purposes oriented toward the project objective.

(d) Availability on a continuing basis.

(e) Willingness to devote the necessary time.

(3) Membership Responsibilities. PAG duties are not extra-curricular. They are part of the assigned duties of every member. It is important that each PAG appointee avail himself of every opportunity to keep abreast of project progress and that he come to each PAG meeting fortified with contributions of a meaningful nature.

(4) Scheduling of First Meeting. The chairman should convene the PAG as soon as possible after the contract is awarded. By so doing, all members will be afforded the opportunity to review the study plan and methodology and make contributions or recommendations as appropriate, thus providing occasion for all parties to the contract to start off together in a well oriented manner.

b. In-Process-Review (IPR). "A formal meeting which is directed by Headquarters, USACDCCSG at the request of the proponent agency at critical points in the development cycle of a project and which is held to evaluate the status, accomplish coordination, and facilitate timely decisions bearing on the future course of the project." This definition was published in USACDCCSG Regulation 71-3, 8 November 1966. Actually, every headquarters at a higher than CSG level appoints committees from time to time to conduct IPR's, depending upon the level of proponency of a particular project. The IPR is used extensively by Army Materiel Command because of the materiel developmental nature of AMC projects. CSG action officers are frequently required to participate as members of IPR panels of other organizations. At CSG, the IPR is not employed nearly as extensively as the PAG. Both the IPR and the PAG are vehicles for evaluating progress and providing advice to the contractor or project officer. CSG employs the PAG more often because it has been adapted more to our purposes and objectives as established in CSG Regulation 71-4.

5. Alternatives for Obtaining Required Contractual Support.

a. General. HQ, CDC has several alternatives in obtaining the required contractual support contained in any given request. These are:

(1) Assign the task to a contractor under an existing continuing contract.

(2) Contract through competition or on a sole-source basis. The determination of any of the methods referred to herein is governed mostly by the type of work to be performed, the knowledge that headquarters staff personnel have as to the capability of the many firms in the particular field, and the urgency of the study effort.

b. If the estimated cost of the study is more than $100,000, - the Secretary of the Army is responsible for reviewing and approving the study. The Chief of Research and Development is responsible for reviewing and coordinating with interested agencies and forwarding such requests to the Assistant Secretary of the Army (R&D) for approval, all projects estimated to exceed $100,000 without regard to the type of funds.

c. If the estimated cost of the study is less than $100,000, the Chief of Research and Development (CRD) is responsible for reviewing, coordinating and approving those OR projects which use RDT&E funds. Responsibilities for contracts of less than $100,000 using other than RDT&E funds are spelled out in Section III, AR 1-110, 22 January 1968.

d. Requests for a new or separate contract or modification of an existing contract are submitted to a contracting office in the form of a letter from Headquarters, USACDC. The request for the contract action will include:

(1) The scope of work.

(2) Technical evaluation factors to be indicated in the request for the proposal.

(3) Citation of funds to finance the contract.

(4) A request that a USACDC individual (military or civilian) be designated the contracting officer's representative or be designated as project officer to be responsible for monitoring the study effort of the contractor and to advise the contracting office of the delivery of the product and the performance of the contractor.

(5) Security requirements check list, DD Form 254.

(6) Recommended sources for obtaining the proposals.

e. With respect to obtaining Headquarters, USACDC continuing-type contracts, the following is the general procedure used:

(1) Approximately 6 months before the contract is due for renewal, requirements are developed as to the potential level of effort to be required during the next contract period. These requirements are condensed into several broad project categories and are used as the basis for preparing the Determination and Findings for submission to the Assistant Secretary of Army (Research and Development).

(2) The procedures outlined in sub-paragraph "d" above are followed in submitting a request to a contracting office. The major difference is that the contract contains authority for the Contracting Officer's representative to assign tasks to the contractor on an "as needed" basis. These tasks may be changed at the discretion of USACDC. Under the terms of the contract and of course, subject to the approval of the contractor, tasks may be assigned under these continuing contracts which will cause the contractor to accelerate the technical effort procured under the contract. This procedure gives USACDC the flexibility in contractual support in meeting program requirements. Under current procedures, continuing contracts are being awarded on a multi-year basis. This provides greater flexibility and longer periods of operation without going through the administrative procedures of contracting. These contracts are awarded initially on the basis of competition.

CHAPTER VII

EVALUATION

1. General. In the first part of this pamphlet it was stated that evaluation of a study or plan is the fifth phase of the process. It was emphasized, however, that it cannot be confined to the fifth or final phase. Some form of evaluation must occur in each of the five phases. Before discussing the final or fifth phase, it is necessary to consider several critical points that are common to nearly all studies. Each point is a vital part of the overall evaluation process.

a. Intended Use of Study Results. The most critical phase of a study effort is the very first step when the sponsor decides what use he will make of the study upon its completion. This purpose will dictate objectives, scope, and timing and may indicate the method to be used. Surprisingly enough, such an important point is overlooked in many studies, and the effort goes from conception to conclusion without the sponsor ever having a very clear idea of the purpose of the study.

b. Necessity for Adequate Time. A reasonable amount of time to conduct a study is essential to success. Time allocated for some studies is unreasonably short. It is unreasonable because the requestor does not really need the information so quickly, or because the time allocation does not permit the study group to develop the subject adequately. Most special study requirements demand the development of a new methodology as well as research and analysis. The time element must be completely evaluated in terms of time and effort.

c. Continuous Monitoring of Contract Effort. During the course of the study, the sponsor must monitor the activity and provide new direction whenever it is needed. This calls for delicacy and tact since Command prerogatives or contractual relationships are involved. Special studies break into new and unexplored areas. The problem is actually defined in the course of the study. The context in which the study is made often changes at higher command levels. The sponsor must evaluate such changes in terms of their relation to the study he is sponsoring and be prepared to redirect his efforts accordingly.

d. Examination for Credibility of Data. The credibility of the data in Army studies has frequently been attacked -- and with good reason. A certain skepticism is needed. Numbers are necessary to the nature of studies but numbers associated with the enemy's capabilities or the performance of future systems are really assumptions. Assumptions control conclusions. Invalid assumptions destroy the utility of studies. When doubt exists, data must be varied within parameters to test the sensitivity of the conclusions. At this point, evaluation must be thorough, logical, and complete. Operational data accumulated by experience should be applied equally to proposed systems and competing current systems, not skewed in favor of the proposed system.

e. Preliminary Evaluation at Project Completion. When the study is completed, the sponsor should make a preliminary evaluation and develop a tentative course of action before circulating the study for comment. Focusing comment on the follow-on actions assists other staff agencies in their review and makes their comments more germane to the purpose of the study.

f. Broad Guidance as Opposed to Definitive Instructions. The initial guidance which some agencies receive for the development of studies frequently is so detailed as to restrict the study unnecessarily or it is written in such a manner that it does not indicate what later evaluation proves to be the actual goals. To preclude unnecessary restrictions, it is often to the sponsor's advantage to seek broad guidance from directing headquarters and, if this is not practical, to evaluate guidance thoroughly and promptly for compatibility with purpose, scope, and objective. Broad guidance can be further defined by judicious inclusion of applicable Essential Elements of Analysis (EEA). These EEA should be listed and designated in such a form that the general questions (of interest to such elements as ICAS) are clearly separated from those of interest to HQ, CSG and to the agency concerned. The number of EEA should be held to a minimum. Additionally, EEA should be written to permit short, specific answers. The sponsor should evaluate the study directive and, using proper channels, should attempt to obtain improvement when guidance directives are cumbersome, ambiguous, or unnecessarily restrictive in nature. In addition to the above, HQ, CSG and agency personnel should recognize the fact that situations will continue to arise in which specific objectives unforeseen for the original study must be undertaken. Also, it must be understood that new requirements are frequently added while a study is in process. CSG and agency action officers are then concerned with the problem of analyzing and evaluating the changes and in minimizing expenditures in terms of manpower, money, and materiel.

g. Judicious Use of PAG's and IPR's. There is, at times, a tendency at all levels to attempt to define and to solve problems by time-consuming and rambling brainstorming sessions with participants drawn from outside the proponent organization. For the development of Basic Derivative Studies, Advisory Working Panels should be established only under exceptional circumstances. When properly used, PAG's and IPR's would serve the same purpose. However, neither the PAG nor the IPR should be scheduled without prior publication of a detailed agenda in which problems and questions requiring resolutions outside the proponent agency are specified. Staff visits are preferred over Advisory Working Panels Inasmuch as such panels tend to dissipate limited group resources, the policy is to limit them as much as possible.

h. Evaluation of BDS Study Techniques. Both HQ, CSG and Agency action officers can improve on study content and conserve time by evaluating proposed Basic Derivative Studies with the following (thoughts) in mind:

(1) Completed BDS should permit agencies, using common approved force models as an analytical tool, to analyze type forces for the time frame under consideration and then to develop field manuals, materiel requirements, and TOE with a minimum of additional research. The analysis of type forces with suitable alternatives, will facilitate the development of the organizations, basic equipment, and doctrine for the Army in the field. Subsequently, the proposed organizations will be compared to those of the present Army, or currently approved study recommendations. All major unresolved differences, gaps, training implications and evaluation requirements resulting from this comparison will be highlighted with suitable recommendations.

(2) It is not the policy of HQ, CSG to require its agencies to develop complete troop lists for each force model. (Situations may arise wherein lists must be developed for specific units in order for agencies to develop suitable recommendations for their own BDS and to develop data as input to other studies.) On the other hand, the provision of type units with a general listing of key systems, equipment, personnel requirements and skills appears to be more applicable to the development of BDS. If subsequently required for implementation, detailed troop lists may be provided in follow-on actions after approval of the BDS.

(3) Since force models are used as analytical tools, HQ, CSG does not recommend that they and their accompanying scenarios duplicate actual contingency situations. This duplication would tend to emphasize the present or near-future time frame. CDC, whose mission is oriented principally to the future, should not be in the business

of "putting out fires" in the present time frame. On the other hand, within the scenarios, CSG encourages the use of geographical areas in which a high probability of US concern is anticipated. Required CDC research and study effort may then be of greater utility.

2. Field Experiments and Troop Tests/Field Evaluations. Troop Tests/Field Evaluations are the final phases of the evaluation process. They take place immediately before the new items are placed in the hands of the user and, in many cases, actually continue after the new doctrine or new items of equipment are being employed by the Army in the field. Field Experimentation and Troop Tests/ Field Evaluation have two characteristics: (1) That of being the most vital part of the evaluative process and (2) That of being an important and often used operations research technique. Field experiments and troop tests/field evaluations will be discussed in the next chapter which is the first of several chapters on operations research techniques.

CHAPTER VIII

FIELD EXPERIMENTS AND TROOP TEST/FIELD EVALUATIONS

1. General. Among the techniques for solution of military problems by operation research methods are field experiments, troop tests, and field evaluations. A field experiment is most profitable near the beginning of the combat development cycle where it is used to provide basic data inputs for studies. Troop tests and field evaluations are normally conducted near the end of the cycle (Evaluation Phase) to test doctrine, organization, and materiel insofar as it influences doctrine and organization.

2. Field Experiments. A Field Experiment is a controlled exercise conducted to collect objective data on a specific problem area for use in developing or evaluating new or improved operational and organizational objectives, concepts, tactics, techniques, procedures, qualitative materiel development objectives or qualitative materiel requirements.

a. Conditions for Experiment. Field Experiments are intended to solve specific problems identified within the combat developments program. Field experiments are conducted under controlled and instrumented conditions designed to influence the specific parameters to be measured, analyzed, and recorded. For the purpose of conducting needed experiments, US Army Combat Developments Command Experimentation Command (USACDCEC) has been established. HQ, USACDC will direct USACDCEC to conduct a field experiment under the following conditions:

(1) When directed by Department of the Army.

(2) When an evaluation by CDC reveals that the experiment is necessary.

(3) When a recommendation has been made to CDC by a subordinate element for the conduct of an experiment. (Justification as required by USACDC Regulation 71-7, Appendix III.)

(4) When a recommendation has been made to CDC by a separate command and is deemed valid.

b. Experimentation Planning Responsibilities. Training Texts for use by USACDCEC in planning, organizing, and training experimental organizations will be prepared by the CSG proponent agency. Draft training texts will be submitted by the agency to HQ, CSG for approval. HQ, CSG will coordinate the text with CDCEC prior to approval. After approval, the final draft training text, with recommended distribution, will be forwarded to HQ, CDC for publication and distribution. An outline plan will be prepared by CDCEC and submitted to CDC for approval and to other interested CDC elements for information.

c. Military and Scientific Interface. The operations of CDCEC will integrate the efforts of the military and scientific staffs. The conduct of field experiments will be based upon sound military principles, and the production of data will be based upon sound scientific principles. A CDCEC experiment may be considered as a scientific examination of military matters by an integrated military and civilian staff of specialists.

d. Appropriate Experimentation Objectives.

(1) Objectives must be amenable to evaluation by analysis of data produced by quantitative measurements taken in the field. They must be related to specific problems. They may be related to any aspect of a military organization to include: tactical and logistical concepts, doctrine, and employment, organizational structure, integration of new weapons or other equipment, performance of weapon systems and administrative and logistical support. Objectives may be oriented toward the generation and collection of operational data required as input to studies, war games and programmed field experiments. Objectives may also be responsive to the requirement for the development of methodology instrumentation and simulation techniques to be used by USACDCEC.

(2) Objectives may be to determine the tactical suitability and the impact of new items of equipment and weapons on the organizational structure, operations and logistical requirements of a unit. However, determination of individual characteristics, capability, and durability of equipment and weapons is not a proper objective for the conduct of a service test.

(3) Field experimentation is inherently time-consuming and expensive in terms of troops, materiel, and funds. Care will be taken to consider only those actions warranting commitment of the limited resources available in view of considerations of time, importance, and availability of troop units for conduct of field experiments.

e. Design and Execution of Field Experiments.

(1) Field experiments will be designed and executed to produce the data necessary for objective response to assigned problems.

(2) Battlefield situations will be devised and detailed "scenarios" prepared to place appropriate stress on the operational, organizational and/or logistical aspects being examined.

(3) The design will provide for minimizing the effects of individual differences in the capabilities of personnel assigned to experimental units and extraneous variables.

(4) Field experiments will include live firing and operational tests if it is necessary to measure the fire capabilities of a weapons system or other equipment.

(5) Experiments will be conducted in a realistic operational environment within the recognized limitations of simulating battlefield conditions.

(6) Typical tasks that can be examined by a field experiment are listed below:

(a) Logistical tasks such as the receipt, storage and issue of equipment and materiel in various types of terrain and weather and during both daylight and darkness.

(b) Combat tasks such as offensive, defensive, and retrograde operations, in various types of terrain and weather and during both daylight and darkness.

(7) The number of replications of an experimentation situation will be sufficient to reduce to a reasonable degree the effect of change or accidental occurrences on the data produced.

f. Methods of Evaluation, Field Experiments. The primary method of evaluation will be by analysis of quantitative requirements made during the execution phase of the experiment. This primary method will be supplemented by judgmental evaluation of those qualitative aspects of performance which cannot be measured in absolute terms. Because of the difficulty, if not impossibility of expressing some military actions in absolute terms, experiments will usually be designed to produce data as a basis of evaluation by one or a combination of the following methods.

(1) Comparative Analysis. The specific aspect of the experimental unit or activity is varied. The level of performance of each variation is measured while holding all other aspects and the environmental conditions as constant as possible.

(2) Determination of Performance. The problem is not to determine the effect of changes, but to measure and evaluate the level of performance of a given organizational or functional element. The aspect to be tested is held constant. Its effectiveness may be measured in a constant or varied operational environment.

(3) Determination of Changes Required to Achieve a Specified Level of Performance. The given level of performance is specified. The problem is to vary the organizational structure, number and types of weapons, tactics, and logistical support until the given level of performance is achieved. The operational and environmental conditions are held as constant as possible.

(4) Evaluation to Determine the Cause of Known Weaknesses. This type evaluation may be used to determine or isolate the cause of an organizational or doctrinal weakness believed to exist in a general area. The evaluation seeks to identify specific causes by determining the effects of varying one organizational element on method of employment at a time, while holding other variables as constant as possible.

(5) Evaluation by Judgment Based Upon Observed Performance. The application of sound judgment cannot be divorced from field experiments. However, the use of judgment as the primary means of evaluation is not the objective of field experimentation. Highly skilled personnel can supplement the evaluations by observing a unit's performance during a field experiment.

g. CSG Staffing of Field Experiments. The responsible staff section for field experimentation by CSG and assigned agencies is the Field Experiment - Troop Test Branch of the Organization and Evaluation Division. All CSG or agency proposed experiments should be submitted to the Field Experiment - Troop Test Branch.

3. Troop Tests/Field Evaluations. Troop Tests/Field Evaluations are conducted in the field for the purpose of evaluating operational or organizational concepts, doctrine, tactics, and techniques, or gaining further information on materiel. Troop Tests/Field Evaluations occupy a position in the Army research and development cycle subsequent to laboratory and field experiments, materiel tests, analyses, and war games. A troop test simulates combat as closely as possible. Within CDC, troop tests will use TOE units or units organized under proposed TOE. Materiel is considered in the conduct of troop tests only insofar as materiel affects the doctrine and/or organization being evaluated. Procedural guidance for the planning and conduct of troop tests is established in USACDC Regulation 71-8, 15 June 1966. The Troop Test Methodology Guide prepared by CORG

provides valuable assistance in the form of lessons learned from past troop tests and discusses troop test methodology in detail.

a. Definitions.

(1) Troop Test. "A test conducted in the field to determine the overall workability and effectiveness of present or proposed organizational concepts, doctrine, techniques, and tactics, or to gain further information on materiel." Implicit in this definition is that materiel items will normally be type classified and will have previously undergone engineering and service testing. A confirmatory equipment test, however, may be conducted concurrently with a troop test, provided confirmatory test considerations do not degrade the overall conduct of the troop test. (The portion in quotes is the definition from AR 73-1. Additional remarks are added for clarity.)

(2) Field Evaluation. "An evaluation conducted under normal operating conditions over an extended period of time for the purpose of examining new and/or revised doctrine and organizations, or examining materiel systems which could affect doctrine and/or organization." Troop tests and field evaluations are similar in design, scope, and conduct. A Field Evaluation is normally of greater duration than a Troop Test. Field Evaluations are normally less rigidly controlled than Troop Tests, and are generally compatible with a major FTX, whereas a Troop Test is not normally compatible with a FTX. For planning purposes, they are considered the same. (The portion in quotes is the definition from AR 73-1. Additional remarks are added for clarity.)

(3) Outline Plan of Troop Test/Field Evaluation. A written proposal, which presents the justification for a Troop Test or Field Evaluation. It is normally prepared by a CSG subordinate agency. The Outline Plan recommends what is to be tested and why, where, and how the test is to be conducted. It recommends the responsibilities for planning, conducting and evaluation and shows resources required in terms of time, personnel, troop units, special equipment and funds.

(4) Abbreviated Plan of Troop Test/Field Evaluation. Contains essentially the same information as the Outline Plan, but in abbreviated form. The abbreviated plan is normally used in proposing troop test/field evaluations 3-5 years in the future for inclusion in the CDC Five Year Troop Test/Field Evaluation Schedule. It is used in those cases where the proposed doctrine or organization to be tested/evaluated has not been developed sufficiently to where an outline plan can be prepared.

(5) Plan of Troop Test/Field Evaluation. "The final plan prepared by the subordinate USACDC group and/or agency that contains the test/field evaluation objectives, subobjectives, essential elements of analysis (EEA), test questions, scope, test forces, area requirements, tactical context, classification guidance, safety considerations, evaluation methodology, outline scenario, doctrinal guidance, refined budget estimate and references." The plan should be prepared in as much detail as possible, so that the Test Directorate conducting the test/evaluation needs only make minor adjustments to the plan to fit it to the local situation. (The portion in quotes is from the USACDC Regulation 71-8.) A plan prepared by the Test/Evaluation Director to fit the Plan of Troop Test/Field Evaluation to the local situation. It is essential that the proponent CDC group/agency coordinate closely with the Test Director to ensure that the Director's plan does not significantly change the objectives and methodology of the Plan of Test/Evaluation.

b. A Troop Test/Field Evaluation may be proposed by any Army Command or CDC Agency, or may be directed by DA or HQ, CDC. As a guide the agency should propose a troop test/field evaluation only when:

(1) It is clear that available military experience and current information are not sufficient to provide sound conclusions on the effectiveness of doctrine, organization, tactics, techniques or procedures, or the impact of newly developed major items of equipment on these concepts or doctrine.

(2) All other means of generating requisite information are considered to be inadequate or more costly.

(3) Advantages to be derived are sufficiently great to warrant the man hours, funds, and other resources to be expended.

(4) The GO, NO-GO Dichotomy Chart at Annex A will be of assistance in determining whether or not a troop test/field evaluation is required.

c. Responsibilities. When the evaluation phase of a study has been reached and the determination has been made as to whether troop tests are required, Agency and Group responsibilities will be as follows:

(1) Agencies.

(a) Accomplish necessary preliminary coordination with elements of USAMC and major Army Commands, to include coordination conferences, during the development of the Troop Test/Field

Evaluation Outline Plan. This coordination is not designed to bypass command channels but is required to insure, to a reasonable degree, that a planned evaluation, on which many man hours will be expended, has a high probability of being conducted as scheduled. HQ, CSG will provide information on all such coordination. Permission to coordinate with applicable Non-Army Agencies will be requested through channels to HQ, CDC.

(b) Provide the USACDC Project Officer. He is responsible to the proponent agency commander. As the troop test or field evaluation progresses through the planning, conduct, reporting and evaluation phases, he will act as the CSG and CDC representative, unless otherwise directed. Duties and responsibilities of the Project Officer are spelled out in detail in Appendix VII to USACDC Reg 71-8.

(c) Prepare and forward the Outline Plan of Test/Evaluation (or abbreviated plan) with recommendation for inclusion in the USACDC Five Year Troop Test/Field Evaluation Schedule. The Outline Plan should be submitted at least 14 months prior to the target date for the conduct of the proposed test/evaluation.

(d) Prepare and forward the Plan of Test/Evaluation at least six months prior to conduct of the test/evaluation, or as directed by CSG.

(e) Assist and coordinate with the Troop Test/Field Evaluation Director to insure that the test/evaluation is conducted according to the objectives and parameters established in the Plan of Test/Evaluation.

(f) Evaluate and recommend the USACDC Command Position on the Troop Test/Field Evaluation Director's Final Report of Test/Evaluation. This should be accomplished NLT five months after the troop test/field evaluation is completed or as directed by CSG.

(2) Headquarters, Combat Support Group.

(a) Reviews and, if approved, forwards proposed Troop Tests and Field Evaluations, with the Outline Plan of Evaluation, to HQ, CDC.

(b) Concurrent with the submission of proposed Troop Tests and Field Evaluations for the target FY, reviews and, if approved, forwards proposed Troop Tests and Field Evaluations for the four year period subsequent to the target FY to HQ, CDC. These submissions will normally be in abbreviated plan form.

(c) Designates the proponent agency that will develop the Plan of Test/Evaluation and furnish the Project Officer(s).

(d) Provides Group Project Officer(s) to direct the proponent agency in the development of the Plan of Troop Test/Evaluation and to assist the major Army command conducting the evaluation.

(e) Reviews, approves and forwards the Plan of Troop Test/Field Evaluation to HQ, CDC, six months prior to the scheduled date of the evaluation.

(f) Reviews, approves, and forwards the Troop Test/Field Evaluation Final Report and proposed command position on the evaluation results to HQ, CDC within Five months after completion of the Troop Test/Field Evaluation.

d. The Outline Plan of Troop Test/Field Evaluation. The Outline Plan (generally formulated by the Agency) should provide the same general information to be later contained in the Plan of Troop Test or Field Evaluation, except in a more condensed form. It will contain, as a minimum, the following elements.

(1) Troop Test/Field Evaluation Title (titles will not suggest a materiel oriented test or evaluation).

(2) Authority (elements of USACDC Concept Program supported or DA Directive; do not list CDOG as authority).

(3) Tentative objectives.

(4) Tentative subobjectives (identified by objective supported).

(5) Tentative Essential Elements of Analysis (identified by subobjective supported).

(6) Scope and tactical context (general).

(7) Estimated Forces (type and size organizations) and Area required (general location, including size of area and type of terrain required).

(8) Estimated Time (FY and Quarters and Duration).

(9) Pre-troop Test Training Required (type, duration, and place of training).

(10) Special equipment requirements.

(11) Estimated evaluation effort.

(12) Tentative Troop Test/Field Evaluation Budget Estimate (based on cost factors of recommended command to conduct troop test/field evaluation).

(13) Recommended Troop Test/Field Evaluation Milestone Schedule (including necessary coordination conferences and in-process reviews).

(14) USACDC Proponent Agency and Name of USACDC Project Officer.

(15) Correlation paragraph.

e. Plan of Troop Test/Field Evaluation. In order to insure that Troop Tests accomplish their intended purpose, the plan provided the major Army Command conducting the tests must be as complete as possible and provide in detail the hypothesis to be examined and methodology that should be used.

(1) Format. At Annex B is an Outline Model for the Plan of Test/Evaluation which is intended for use as a format guide and check list to ensure preparation of a complete and logically organized plan of test/evaluation.

(2) The Plan of Test/Evaluation is structured around three main sub-plans: The Control Plan, Data Collection Plan, and Analysis Plan. For a detailed discussion of these plans refer to the Troop Test Methodology Guide prepared by CORG

(a) Control Plan. If a troop test is thought of as a cause-effect relationship, the control plan is the pre-set schedule of causes. Since maneuver establishes the situations in troop testing, the core of the control plan is the scenario. The Control Section directs the field play with the intent of making it adhere precisely to the scenario (which states the actions required to generate data necessary to evaluate the proposed concept). Of importance also are the control procedures to be used during the conduct of the test evaluation. Other elements are the control organization, duties of controllers and their training, and administration and support.

(b) Data Collection Plan. The Data Collection Plan provides for complete and accurate recording and reporting of all necessary data. The data collection plan has several necessary

elements: data forms or questionnaires to record observations, collection schedule, and support requirements. The plan also proposes the data collector organization, describes collector duties and collection procedures, and outlines training requirements for the data collectors.

(c) Analysis Plan. The Analysis Plan (called Evaluation Plan in the Methodology Guide) details the data-handling process and analysis logic, from the raw data to complete analysis of each test objective. The principle of pre-set procedure is most important here because personal bias can most easily distort test results during analysis of data collected. The pre-set procedure includes steps for: checking field data for completeness, identifying voids, correction for incomplete or invalid data, judging validity of the data, computing test findings, drawing conclusions, and making appropriate recommendations in the final report. The analysis plan should also provide for the proposed analysis organization, duties of analysts, and training requirements.

f. Development of Essential Elements of Analysis (EEA). Because of the extreme importance of the EEA in the successful conduct and derivation of accurate results, their formulation is perhaps the most singularly important act of the originating agency. EEA are those questions specifically designed to obtain data that will provide an answer in a particular problem area or information required to conduct an evaluation in a particular functional area. EEA are based on a derivation process beginning with the doctrine and/or organization to be developed. Sequential procedures in developing EEA are as follows:

(1) Input. Identify the doctrine and/or organization to be examined and evaluated.

(2) Objectives. Major elements of the hypothesis to be tested, each of which are equally essential to the acceptance of the overall doctrine and/or organization being examined. Objectives may be directed to this or higher headquarters and/or derived from the doctrine and/or organization to be examined.

(3) Subobjectives. Major elements of each objective that may or may not be equally essential but contribute to achievement of results that would indicate accomplishment of the objective. As indicated in Appendix IX, USACDC Reg 71-8, weighting of subobjectives by a consensus of military judgment is appropriate.

(4) Design of EEA. In designing EEA, the most logical approach is to currently examine the doctrine and/or organization against which the Troop Test/Field Evaluation

hypothesis (doctrine and/or organization) will be measured and the functional areas involved in the proposed doctrine and/or organization to be evaluated. In addressing the functional areas involved, use will be made of the Army Function --Phase-Mission-Matrix (page II-5 of Part 1, Methodology Notebook). The analysis will include sub-functions and tasks and sub-subfunctions and subtasks as spelled cut on pages 34 and 35, Annex A to Appendix 5 of USACDC Reg 71-8. After reviewing the tasks, subtasks, functions, and subfunctions, those that are crucial to the examination of the proposed doctrine and organization will be selected and screened for prospective difference in performance. The tasks and subtasks for which EEA must be designed will then be defined and measurement techniques named. The final step is the establishment of relative weights for the EEA.

(5) A further breakdown of EEA may be required. The number of levels of breakdown depends on the size and complexity of the test. It takes one or more questions to answer an EEA, and ultimately, each breakdown must arrive at the level of a Data Form Question. In this respect, the more specific the requirement stated at the EEA level, the less complex is the breakdown. The final level of question breakdown, the Data Form Question is reached when each question:

(a) Is relevant and essential to the next higher level of analysis.

(b) Is objectively answerable, preferably by a number, a single work, or a checkmark.

(c) Is answerable by one collector in one location.

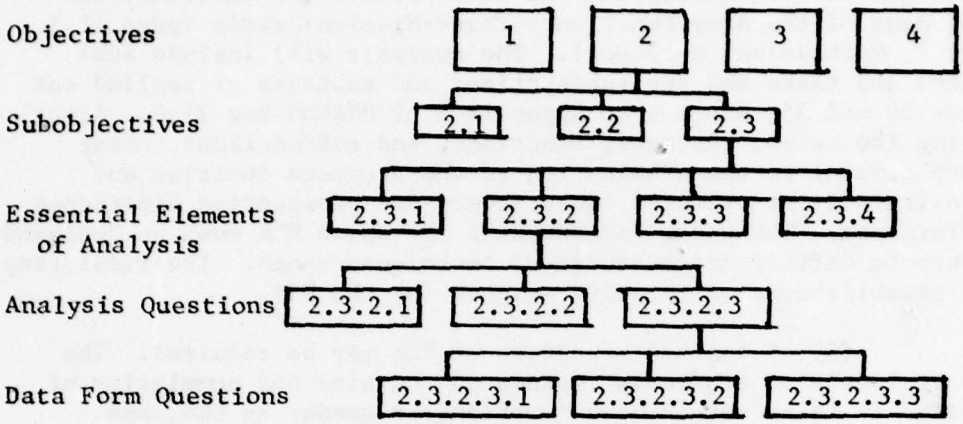
(d) Requires no judgment.

(e) Does not require the collector to recall a previous action.

(f) Is answerable in a clear and simple manner.

(g) Does not require specialized knowledge on the part of the collector.

The breakdown of EEA as described above is illustrated as follows:



g. Pilot Test. It is usually necessary to conduct a pilot test prior to the actual test/evaluation to check out all aspects of the Control Plan and Data Collection Plan, and to afford additional training to Controllers and Data Collectors. The pilot test can be expected to uncover some problem areas for which minor changes in test questions and control and data collection procedures can be made. For a more detailed discussion of the pilot test refer to the Troop Test Methodology Guide.

h. Conduct of the Troop Test/Field Evaluation. The major command conducting the test/evaluation is responsible for: providing troops and the test/evaluation directorate, conduct of the test/evaluation, and preparation of the final report. It is essential that the CDC Project Officer maintain close and continuous coordination with the Test Director to insure that the actual conduct of the test/evaluation does not vary significantly from the Plan of Test/Evaluation. If changes in the test/evaluation are required, the Project Officer should assist the Test Director to minimize the effect of the change on the overall objectives and validity of the test/evaluation.

i. USACDC Command Positions on Final Reports of Troop Tests and Field Evaluations. The official USACDC Command Position is based on the USACDC Evaluation, a detailed review and analysis of reported results of the troop test or field evaluation, comments of other interested major Army Commands. To formulate the position, the following steps are necessary:

(1) The Test/Evaluation Director prepares a comprehensive Troop Test/Evaluation Final Report to include a statement of troop test/field evaluation validity, methodology used, and conclusions and recommendations. This report is forwarded through command channels to HQ, USACDC. Concurrently, the Director forwards ten advance copies to the proponent agency so that preliminary evaluation of the test results can begin; 100 copies are also forwarded direct to HQ, CDC for distribution to and comment on by other groups agencies and by appropriate major Army commands.

(2) Major Army commands evaluate the results and forward comments, recommendations, concurrences, and nonconcurrences to HQ, CDC with information copies to the proponent group and agency.

(3) Proponent Agency Responsibilities. Using the information received from the Director, the proponent agency conducts a detailed review and analysis of the final report and prepares a proposed USACDC position. This proposed position is coordinated with all interested CDC groups and agencies and with appropriate USCONARC Service Schools prior to submission through channels to HQ, CDC. In addition, the primary-interest agency prepares a staff coordination briefing and a final information briefing on the proposed position to be presented at HQ, CDC, on call.

(4) Proponent Group Responsibilities. CSG will resolve any conflicting position to HQ, CDC. Any revision (rewrite) of any or all of the evaluation and/or position will be accomplished as deemed necessary by HQ, CSG, prior to submission to HQ, CDC. Additionally, HQ, CDC (if it has proponency) will attempt to resolve conflicting positions of those agencies not under its Command but from which comments were solicited.

REFERENCES:

a. Letter, CDCRE-E, subj: Troop Test Methodology Guide, 26 Feb 68.

b. AR 71-3, User Field Tests, Experiments and Evaluations, 19 Mar 68.

c. USACDC Reg 71-7, Field Experimentation, 21 Jun 66.

d. USACDC Reg 71-8, Procedural Guidance for the Conduct of Troop Tests and Field Evaluations, 15 Jun 66.

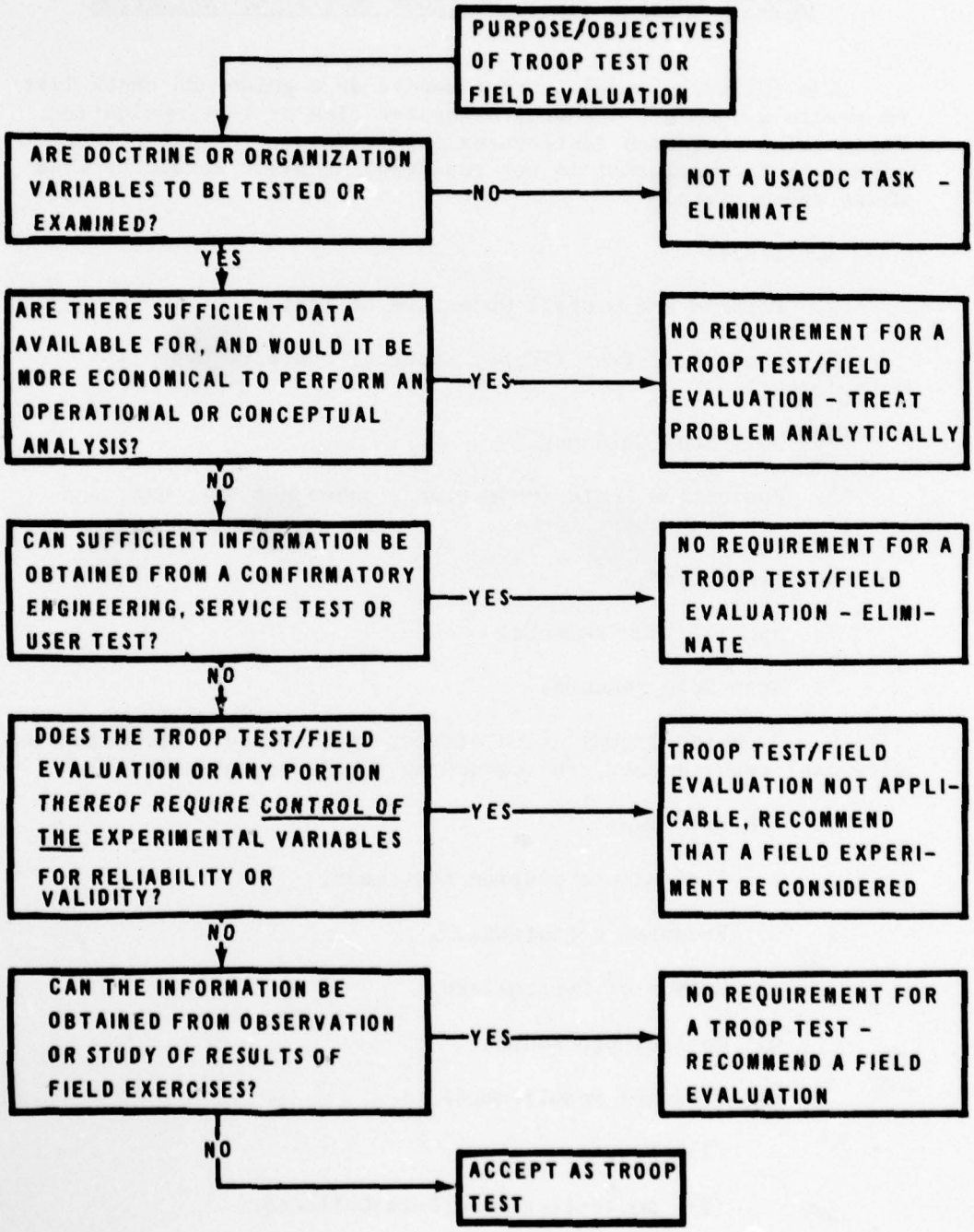
ANNEXES:

A -- GO, NO-GO Dichotomy Chart

B -- Outline Model for Plan of Troop Test/Field Evaluation.

ANNEX A

GO, NO-GO DICHOTOMY



ANNEX B

OUTLINE MODEL FOR PLAN OF TROOP TEST/FIELD EVALUATION

The following model is recommended as a guide and check list to insure a complete and well organized plan of test/evaluation. Recognizing that each test/evaluation is unique in itself, strict adherence to the format is not required; annexes should be used where appropriate.

1. Title.

2. Purpose and Overall Objective of Test.

3. Concept of Test (Scope, tactical context, overall methodology).

4. Doctrinal Guidance.

*5. Evaluation Logic (Objectives, subobjectives, EEA, and *questions in flow chart form*).

6. Troop List.

7. Special Requirements.

8. Area Requirements.

9. Proposed Organization of Test Directorate. (Organization, personnel requirements, and equipment support requirements.)

10. Control Plan.

    a. Controllers' mission statement.

    b. Proposed organization.

    c. Duties of Controllers.

    d. Control procedures.

    e. Training requirements.

        (1) Troops.

        (2) Controllers and Data Collectors.

(3) Pilot Test.

f. Scenario.

g. Administrative (security, safety, commo., etc.)

11. Data Collection Plan.

a. Data Collectors' mission statement.

b. Proposed Collection organization.

c. Duties of Collectors.

d. Collector training (integrate with controllers).

e. Data collection/reporting procedures and schedules.

f. Questionnaires and data collection forms.

12. Analysis Plan.

a. Evaluator's mission statement.

b. Evaluation organization.

c. Duties.

d. Data Reduction: worksheets, computations, formats,etc.

e. Performance criteria.

f. Validity.

g. Weighting.

13. Budget Estimate.

14. References.

*NOTE: The Logic Diagram, as shown on pages xii and 43 of the Methodology Guide, visually illustrates the relationship of objectives, subobjectives, EEA, questions, and data elements. This technique would be helpful to Test Controllers, Data Collectors, and Evaluators in visualizing their tasks.

CHAPTER IX

COST EFFECTIVENESS

1. General. Cost-effectiveness analysis, operations research, and systems analysis differ in that the problem involved in each is different. If the problem is to determine significant differences in the costs of resource requirements among alternatives for carrying out some specified task, the analysis is generally referred to as a cost-effectiveness analysis. A cost-effectiveness analysis typically stresses the determination of an adequate but least cost scheme, sometimes accepting as inputs the objective of the system or strategy and the list of alternatives. Emphasis of the operations research analysis is usually on the use of the techniques of mathematics, or logical analysis, to help a client improve his efficiency in a situation in which everyone has a fairly good idea of what "more efficient" means. The systems analyst, on the other hand, is likely to be forced to deal with problems in which the difficulty lies in deciding what should be done, not simply in how to do it. The system analysis, thus, puts greater attention on the suitability of the task and the augmentation of alternatives. Part I (Chapter VIII), USACDC Methodology Notebook for Action Officers, provides a brief discussion of the meaning of and the Army need for cost/effectiveness analysis. It is not possible, within the scope of Part II of the Methodology Notebook to describe the many techniques of such an analysis or to define systematic steps in its accomplishment. It is practical, however, to provide a brief description of the manner in which cost/effectiveness analysis is employed within CSG and its assigned agencies. It is important that each action officer possess sufficient background in the rudimentary fundamentals of cost effectiveness analysis techniques to enable him to scrutinize contractual studies and/or proposals and to formulate valid judgment on contractual methodology and scientific procedures. To perform such judgment, it is necessary, as a minimum, that an action officer be familiar with the terms and concepts of this chapter.

2. Cost Effectiveness Compares with "Estimate of the Situation". Cost effectiveness analysis is based on the economic concept that all military decisions involve the allocation (best use) of limited resources among competing requirements. This same concept is embodied in Army decision processes. It is used by a combat commander when he makes an estimate of the situation. The company commander goes through the same process in deciding how to spend his company funds. Although cost effectiveness analysis and

the estimate of the situation are similar in many ways, they differ in several aspects. The estimate of the situation usually involves an effort to solve today's problems today. More often than not, the cost effectiveness study concerns itself with the problems of the future. Another severe constraint on the estimate of the situation is the time factor. Information is usually incomplete and the time available before a decision is required often does not permit filling in gaps. Time usually does not permit testing the range of the dependence of the proposed course of action on the staff estimates and planning assumptions. On the other hand, military cost effectiveness analysis is not a decision process but an aid in facilitating decisions that must be made now in regard to development, force composition, and logistical and manpower policy problems in order to be prepared for wars in the future. The analytical techniques employed in cost effectiveness analysis supplement those of the estimate of the situation because, as we look into the future, the presence of certainties lead to a large number of variables. Some of these variables are subject to our control, some to the enemy's and others to no one's control. But all are variables, and all are interdependent. It is in this environment of uncertainties and flexibility in use and interchangeability of resources (people, dollars, and hardware) that cost effectiveness analysis is a useful aid. The basis of cost effectiveness analysis is that there are alternate ways of reaching an objective and each alternative requires certain resources and produces certain results. The cost effectiveness analysis examines systematically and relates costs, effectiveness, and risks of alternative ways of accomplishing an objective and designing additional alternatives (proposed courses of action) if those examined are found wanting. A cost effectiveness analysis seeks to quantify what can be logically calculated so that the decision maker knows the extent to which intuitive judgment must be used in making a decision.

3. Essential Elements. The essential elements of a cost effectiveness analysis are:

a. Objective(s) (functions to be accomplished).

b. Alternatives (feasible ways of achieving the desired military capability or accomplishing the function).

c. Cost of resources required by each alternative.

d. A set of mathematical or logical relationships among the objectives, alternatives, environment and resources (models).

e. A criterion for choosing the preferred alternative.

4. The Objective. To design alternatives properly, the problem must be analyzed to determine the real functional need underlying the requirements for certain organizations and hardware systems. Close examination of objectives stated only in terms of specific organizations or systems often discloses that the net result is not a significantly new capability but a relatively minor product improvement. There are practical limits on the definition of the objective. Every military activity is part of a larger activity and it is necessary to draw the line at some point. However, the objective should not be unduly restricted by confusion with performance characteristics such as speeds, weights, muzzle velocities, hit-kill probabilities, and so forth.

5. Cost. The cost of each alternative is determined based on incremental costs. These are the net costs of adopting the alternative. Such costs are determined after (due) allowances for those resources already paid for regardless of whether the alternative is adopted, and would be available for the alternative if it were adopted. In determining the cost of an alternative, all the resource implications are considered. For example, the cost of adopting a new radio would include not only the cost of the radio and its development, but also the costs of training people to operate it, the total cost of maintaining the radios, and the costs of the additional radios required for maintenance float, replacement, combat consumption and so forth. Costs need not be stated in precise terms--down to the last dollar; however, they must be accurate enough to allow meaningful relative discrimination between alternatives. Usually cost estimates are tested by sensitivity analysis. These are repetitive analyses using different quantitative values to determine if the results are sensitive to the values assigned. Such analyses give the analyst a better understanding of how much uncertainty is involved if there are significant errors in the cost estimates. He can then better judge if the investment is worth the payoff considering the uncertainties involved.

6. Models. Models are used in cost effectiveness analysis to cope with the host of variables that are inherent in problems of the future. A model is simply certain relationships expressed in some way to simulate real or expected conditions in order to foresee the expected outcome of a course of action. The model assists in simplifying the problem, in identifying the significant components and interrelationships, in determining which variables are especially important for the decision at issue, and which variables can be suppressed. Models range from simple graphs to complex equations and can also take the form of a wargame or field maneuver. All models are abstractions of the real world and their validity depends on the proper selection of assumptions, the correctness of the relations portrayed, and the pertinence of the

factors included in the model. Some models are difficult to construct because some variables cannot be definitively quantified. The influence of a variable that cannot be quantified must be specifically addressed in the model unless it can be demonstrated by logic or analysis that the variable is trivial, affects all alternatives roughly the same, or the results are insensitive to the variable. Models that portray relations incorrectly also lead to false results. Some models depend on extrapolation which assumes that trends will continue uninterrupted. Such models lend themselves readily to mathematical treatment but are often erroneous because of failure to consider what is called the Law of Diminishing Returns.

Models can be classified into two general types: deterministic and probabilistic. It is possible to create an almost exact (deterministic) model of an item of hardware and subject it to test. The final product of the model will then closely approximate the results from the actual hardware. On the other hand, most military problems are, by nature, made up of uncertainties. Therefore, they are considered as probabilistic when the uncertainty is identified as a probability factor.

The construction of models to evaluate effectiveness is often difficult. The difficulty arises in selecting the criteria of effectiveness, the more abstract the system or organizations become, the more difficult the criterion of effectiveness measure becomes. The more unlike the alternate systems are, the greater the difficulty in reducing them to a common denominator criterion of effectiveness measurement. Sometimes, each system requires a criterion of effectiveness that is all its own.

There is a tendency for cost effectiveness models to become mathematical and abstract, thereby making them difficult to understand. A good cost effectiveness analysis strikes a balance in the use of models between simplicity and retention of enough detail to insure that the expected outcome of an expected action will be adequately portrayed. In any case, all models have certain common elements. These are broadly stated as a definition of the problem, principal factors or constraints, verification and the decision process -- or application of criteria. The validity of conceptual or mathematical models cannot be verified in a cost effectiveness analysis by controlled experiments. At the best, these models can be tested by evaluation of their workability.

7. Role of Judgment. Judgment is used throughout a cost effectiveness analysis in the same manner as is an estimate of the situation or a staff estimate. Judgment is used in analyzing the objective, deciding which alternatives to consider, which factors

are relevant and the inter-relations among these factors, which numerical values are to be used, and how results are to be interpreted. (In the earlier portions of this pamphlet, the statement was made that in all operations research, the process of evaluation was on-going and continuous; that some form of evaluation has to occur during every phase of a study. A cost effectiveness analysis is no exception.) The goal of a cost effectiveness analysis is to keep all judgments in plain view and to make clear the logic used. It also shows the sensitivity of the results to the significant judgments made. The depth of a cost effectiveness analysis is tempered by the time and manpower available and the importance of the subject matter. A cost effectiveness analysis requires resources. It must serve as an aid to the making of decisions and not be a mere intellectual exercise.

8. Criteria. The most widely used criteria in Army studies for selecting the preferred alternative are usually based on either equal cost or equal effectiveness of the alternatives. Another method known as incremental effectiveness at incremental cost is used in special cases. In the equal cost form, it is assumed that there is an arbitrary fixed budget or series of fixed budgets, and the analysis determines which alternative gives the greatest effectiveness for the same expenditures of resources. In the equal effectiveness form, a specified and measurable military effectiveness (capability) is stated and the analysis is to determine which alternative achieves this effectiveness at least cost. The incremental effectiveness at incremental cost method relates the increase in effectiveness achieved to the associated increase in resources involved. This method is normally used only as a last resort when neither costs nor effectiveness of alternatives can be made equal, e.g., when a capability based on a new technology is to be added to the force and this new capability cannot be approximated by any practical combination of existing materiel and men.

9. Review of Studies. There are numerous ways of reviewing a study. They vary with time available and resources. It is suggested, however, that the points listed below be checked specifically in the early stages of a review:

a. Statement of criteria used to judge effectiveness.

b. Statement of criterion used to select preferred alternative.

c. Use of incremental costs.

d. Explanation of logic of models.

e. Presence or lack of analysis of sensitivity of the results to significant data and assumptions. Without these elements being present, the study will probably be of poor quality.

f. Army-conducted studies containing cost effectiveness analysis usually do not have a uniform organizational pattern but many generally follow the Staff Study Format. On that basis, the key questions to be considered are listed below. These questions, which will assist the proponent agency in formulating the study and will be of vital benefit to the person analyzing it, are as follows:

(1) Is the problem stated the real problem? An improper statement of the problem often results in either studying the wrong problem or precluding consideration of worthy alternatives. These defects are usually avoided by a statement of the problem in terms of a functional need--the job to be done. Often, there will be a practical limit on the depth of the functional need. To make it too deep and too all inclusive will restrict the workability of the research tools and make the study unmanageable.

(2) Does the study identify implied significant components of the problem that must be fully treated in the study? Some of these implied functions are often not apparent at first. The reviewer should watch for implied significant component parts of the problem that are neither identified nor treated fully in the study. He should also watch for other problems that are opened up or revealed by the study that should be further investigated.

(3) Are all assumptions identified? The reviewer should watch for assumptions that are not identified as such because assumptions imply a limitation or a judgment. They also affect the study results.

(4) Are the assumptions unduly restrictive? Assumptions are properly used to narrow the scope of a study to manageable proportions. However, they should be examined to determine whether they unduly restrict the study by eliminating possible significant alternatives or by narrowing the scope of consideration to the point that the conclusions and recommendations may be in order.

(5) Do any of the major assumptions unjustifiably treat quantitative uncertainties as fact?

(6) Do any of the major assumptions treat qualitative (as opposed to quantitative) uncertainties as fact?

(7) Are the major assumptions reasonable? The study should document or provide some explanation as to why an assumption was made.

(8) Are current capabilities adequately considered among the alternatives? Current capabilities should not be omitted from consideration in construction of alternatives except for valid reasons that are clearly stated. By considering them (much of their costs having been paid for), the study can show the difference between effectiveness and costs that result from the adoption of the proposed new system or organization.

(9) Are "trade-offs" with existing systems or organizations adequately considered within the alternatives? Where appropriate, the design of alternatives should consider "trade-offs." Possible examples are: (a) in studying the use of proposed transport aircraft an alternative might include reduction in other means of transport; (b) in a study on an improved fire control system, an alternative might include a reduction in ammunition stockage.

(10) Are the appropriate capabilities of the Air Force, Navy, and Marine Corps considered among the alternatives?

(11) Are mixtures of systems or organizations considered among the alternatives?

(12) Are any feasible and significant alternatives omitted?

(13) Is the study adequately documented? A key element of systematic analysis is sufficient documentation of methods and sources so that with the same material, other study groups can arrive at substantially the same results.

(14) Are the facts stated correctly? The reviewer cannot check every empirical solution, but he can and should spot-check.

(15) Are the facts stated with proper clarification? Factual material should be checked not only for accuracy but also for completeness. Some material may be factually correct in isolation but may take on a different significance when other facts are added.

(16) Are findings and data from field exercises and field tests used?

(17) Are the data from supporting wargames valid?

Basically, a wargame involves a hypothetical situation. The play is determined by mechanistic rules or judgments made by individuals or both. Their output is no better than the judgment and/or the rules established for the games.

(18) Are the performance characteristics valid? Here, the reviewer should examine the source of the data. Performance characteristics based on a manufacturer's claims are often too optimistic. Sometimes, research installations derive their performance characteristics under controlled conditions. They can sometimes produce misleading results.

(19) Are any of the data derived from questionnaires? Here, the reviewer should examine for validity of questions, adequacy of the sample, and expertness of personnel questioned.

(20) Are guesses and intuitive judgment defined?

(21) Is the cost model identified?

(22) Are the cost estimates relevant?

(23) Are incremental costs considered? Sunk costs should be excluded. (Research, development, and investment costs of existing systems are sunk costs).

(24) Are directly related support costs included? Cost estimates of systems or organizations should include the proportionate costs of other units or elements required in direct support. For example, the cost estimate of HAWK battalions should include the costs of the associated HAWK direct and general support detachments.

(25) Are Combat Consumption, Replacement/Consumption, and Maintenance Float costs included? Cost estimates for the major equipment items should include not only the operational equipment assigned to organizations, but also the costs for those additional items required for initial stockage as well as replacement items over the period in which the system is to be in use. If the resource implications for procuring and maintaining authorized maintenance float, replacement/consumption and combat consumption stockage are excluded, the total costs of the system alternatives may be significantly misleading. For example, a common error is to include only the cost of the basis load of ammunition and to neglect the cost of the additional ammunition requirements for support of the weapon system or organization.

(26) Are all training costs included? The resource implication of training military personnel can be significant.

Training costs usually include such items as: (a) procurement of equipment utilized for training purposes; (b) construction of any necessary additional facilities; (c) operation and maintenance costs of the facilities; (d) the pay and allowances of the trainees.

(27) Are construction costs included?

(28) Are the Cost Data reasonably accurate? The reviewer should spot-check and examine the sources of the data. Data furnished by manufacturers should be viewed critically.

(29) Are cost aspects of all alternatives treated in a comparable manner? Inconsistency in handling the cost aspects of competing alternatives prevents an objective evaluation of their comparative or relative costs and usually leads to erroneous conclusions.

(30) Are the cost estimating relations valid? Cost estimating relations may be crude factors, simple extrapolation of recent experience, or complex equations with many variables. In all cases, the purpose of a cost estimating relation is to translate a specification of a physical resource into a cost.

(31) Is an amortized cost used? If so, the reviewer should attempt to convert amortized costs into total program costs and use such costs for comparative purposes.

(32) Were peacetime or wartime costs included? The use of peacetime costs only may indicate that System A is preferred; if wartime costs were used, the same study may have concluded that System B is preferable.

(33) Was a wartime ordnance cost per mission used? The use of wartime ordnance cost per mission should be reviewed carefully. Often, this approach includes only the ammunition costs expended during a brief battle. It fails to mention the significant costs associated with developing, buying, and operating the system in peacetime.

(34) Was a dollar cost assigned to the loss of human life? If so, delete it. In the U.S. Army, human casualties are treated in the overall value of cost considerations, but not in dollars.

(35) Is the sensitivity of cost assumptions examined? For example, would ten years of peacetime operations as opposed to five make a significant difference in the relative costs of the alternatives.

(36) Are the models adequately identified and explained.

(37) Are cost and effectiveness linked logically?

(38) Does the model treat the problem in a system context? Models should provide for the proper relations among subsystems so that the full implications of a change in one part of the system will be reflected in the rest of the system?

(39) Does the model allow for enemy reaction? A major aspect of the effectiveness of our system is the degree to which it makes enemy adaptation either technologically difficult or economically unattractive.

(40) Are straight extrapolations used without proof?

(41) Are deterministic and probabilistic models used properly? A deterministic model uses relations of the type, "If A is 5, then B is always 8". A probabilistic model uses relations of the type, "If A is 5, then B will be 6 to 10 in 50% of the cases, 4 or 5 in 25% of the cases, and 11 or 12 in 25% of the cases."

(42) Are the models intuitively acceptable? Models tend to become mathematical, and many are difficult to understand even in their broad aspects. Yet, overly simplified models tend to become superficial by limitation in choice of detail and omission of important variables. The objective of a good model is to be near enough to reality so that the model outputs can be used to predict some portions of the future with an acceptable degree of confidence.

(43) Are the measures of effectiveness identified?

(44) Is the effectiveness measure appropriate to the function or mission?

(45) Do the effectiveness measures ignore some objectives and concentrate attention on a single one?

(46) Are performance measures mistaken for effectiveness measures? The speed at which a unit can attack the enemy is not in itself a measure of its ability to defeat the enemy.

(47) Is the effectiveness calculated on the basis of either a cooperative enemy or an omnipotent enemy?

(48) Is the effectiveness measured by analysis of wargames?

If so, the reviewer should look to sensitivity analysis for results. As a rule, wargames are questionable means for measuring effectiveness because of the difficulty of testing the sensitivity of the results.

(49) Is the evaluation of effectiveness based on straight extrapolation?

(50) Are the operations of other services ignored?

(51) Is the impact on other Army operations ignored?

(52) Are some aspects of effectiveness incommensurable or unmeasurable?

(53) Does the effectiveness of a future system take into account the time dimension? The effectiveness of future systems is often dependent upon when they can be available for operational use and the total operational life span of the systems.

(54) Are expected and average values used incorrectly to measure effectiveness? It is an error to employ an expected or average value as part of a measure of effectiveness <u>if the objective really required a specified minimum</u>.

(55) If quantitative measures of effectiveness are unattainable, is a qualitative comparison feasible?

(56) Is the effectiveness sensitive to changes in assumptions? If so, the reviewer should isolate the degree of dependence and determine if it is acceptable.

(57) Are the criteria properly identified?

(58) Are the criteria consistent with higher echelon objectives?

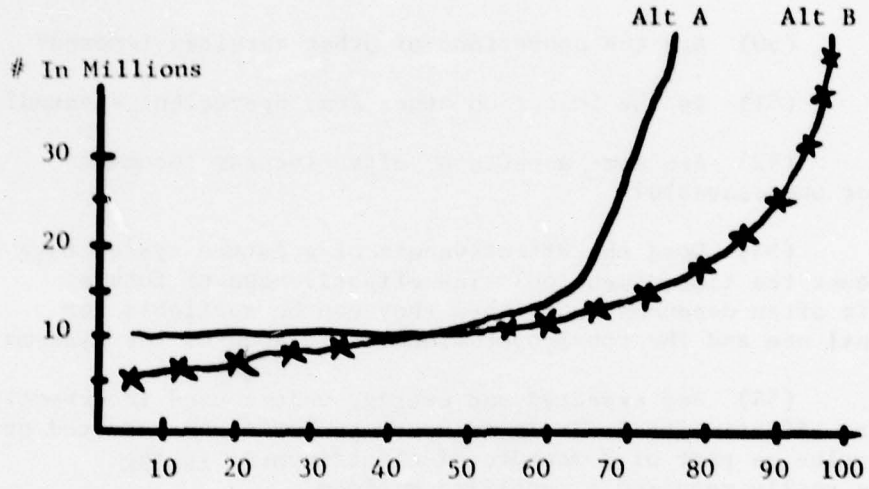
(59) Are the criteria too general?

(60) Are the criteria overdetermined? For instance, a criterion that states, "to maximize the damage to the enemy while at the same time minimizing the cost to the U.S." is grossly overdetermined.

(61) Are good criteria applied to the wrong problem? At times a valid criterion for one element of the problem is incorrectly applied to the total problem.

(62) Is the absolute size of gain or cost ignored?

Some alternates change in effectiveness when projected in units, dollars, time or other factors.



(63) Are the conclusions and recommendations logically derived from the material contained in the study?

(64) Have all the significant ramifications been considered in arriving at the conclusions and recommendations

(65) Are the conclusions and recommendations really feasible in the light of political, cultural, policy, or other considerations?

(66) Are the conclusions and recommendations related to the limitations of the study?

(67) Do the conclusions and recommendations indicate bias?

(68) Are the conclusions and recommendations based on external considerations?

(69) Are the conclusions and recommendations based on insignificant differences?

(70) If priorities are listed, are they meaningfully stated?

(71) Are the conclusions and recommendations intuitively satisfying? If the study fails to demonstrate by data, models, and other means that the reviewers intuition was right or wrong, then further examination is required to determine if some subtle considerations have not been considered because of oversimplification or other reasons which the reviewer intuitively knows are present.

10. Contractor Selection. During the last several years, the Department of Defense has been increasingly concerned about the economic implications of awarding contracts on the basis of acquisition price only. The Armed Services Procurement Act of 1947 allows a much broader approach by stating, "Award shall be made ... to the responsible bidder whose bid ... will be most advantageous to the Government, price and other factors considered." In the CSG contractual research program, it is frequently important that many diverse elements of various contractor capabilities be analyzed before a contract is let. As previously stated, the low bid is not always the most important factor. Although all CSG research contracts are formally awarded at USACDC and AMC level, contracting officers will generally lend a sympathetic ear to a CSG or agency justified request for a recommended contractor. When recommending a contractor for a specific research contract, the initiating agency should do so only after considering all elements of importance to the U.S. Government. These considerations should include but not be limited to whether the proposal contains unnecessarily expensive components or devices, costly manufacturing processes or methods that are not essential, the use of critical materials, restrictions which do not enhance the military value of the end product, unnecessary time expenditure for data accumulation, and/or lack of reliability of past performance.

CHAPTER X

HUMAN FACTORS AND SOCIAL SCIENCE RESEARCH

1. General. AR 70-8 sets forth the scope, objectives, application, and coordination of human factors and social science research. It covers:

a. The basic and applied portion of the DA research and development program concerned with discovery, development, and application of human factors and social science principles and techniques for more effective use of military and civilian personnel.

b. Increasing the efficiency with which Army personnel perform their duties, operate and maintain their equipment, serve their weapons, give and accept commands, adopt to environmental and psychological stresses, and acquit themselves in combat.

c. More effective conduct of special warfare and related cold war activities.

2. Objectives. The objectives of the program are:

a. Improved fulfillment of the personnel requirements of DA through research in the fields of personnel measurement and utilization.

b. Improved performance of military and civilian personnel through research and development in the field of training methods, techniques, and devices.

c. Improved motivation and leadership through studies in those fields.

d. Improved compatibility of men and the weapons and equipment which they are required to operate and maintain, through basic and applied studies and research in human factors engineering, man-weapons system analysis, and psycho-physiology.

e. Improved performance in counterinsurgency and unconventional types of warfare and psychological operations capabilities through social and behavioral science studies of methods for influencing indigenous troops and populations in foreign areas and other social and behavioral science studies as may be

needed for direct support of the special warfare and related cold war activities.

f. Improved capability through basic research in behavioral and social sciencies.

3. Responsibility. The Chief of Research and Development (CRD) has Army staff responsibility for planning, programming, coordinating, and supervising DA non-materiel research in human factors including research and development policies, funds, projects, tasks, and priorities relating thereto which are essential to discharge of the responsibility. The sponsor of a research effort is responsible for providing (or assisting in obtaining) advice and guidance when requested to do so by the research agency and for providing (or assisting in obtaining) background data and information applicable to the research effort.

4. Initiating Proposals. An Army staff agency, a command, an individual, a research agency, or a contract agency may initiate a proposal for human factors research. A proposal originating in an agency not authorized to conduct the particular research will be referred through normal channels to the CRD for approval and allocation to the appropriate research and development agency. Agencies may request assistance from CRD to translate military requirements into research proposals.

5. Research Activities.

a. The US Army Personnel Research Office will undertake studies in personnel measurement directed toward optimal employment of Army personnel in a variety of military settings.

b. The US Army Materiel Command (USAMC) is responsible for human factors engineering in support of the design and development of future materiel components and systems, except in the case of the Corps of Engineers.

c. The Chief of Engineers is responsible for human factors engineering of materiel within his assigned area of development responsibility.

d. The Surgeon General is responsible for maintaining a comprehensive basic research program in psychphysiology designed to support the human factors program.

6. Program Coordination and Approval.

a. Annually, the CRD will request Department of the Army commands and agencies to submit their requirements, in order of

priority, for research to be undertaken during the ensuing fiscal year. The requirements thus submitted will be combined with the specific requirements derived from long-range research plans to form the basis for the work programs of the research activities.

b. Before 15 May each year, each responsible agency (see paragraph 5) will submit to the CRD a proposed work program for that portion of its research supported by Army RDT&E funds. (This excludes that human factors engineering which is supported directly by funds from materiel development projects.)

c. Department of the Army commands and agencies having an interest in such research will review the appropriate work programs to determine the responsiveness of the research program to the requirements of their agency.

d. Action to revise CRD-approved work programs will be accomplished in coordination with the sponsoring agency, OCRD, and other interested agencies. Proposed changes to an approved work program will be submitted to the CRD for approval. Task statements will be revised for each task affected by an approved modification to a work program.

7. Coordination. Each agency engaged in human factors research will maintain coordination to keep informed of the activities of the other research agencies and to eliminate undesirable amplication of work. Information will be exchanged by routine distribution of progress reports, completed task reports, direct correspondence, and visits of working level scientists and technologists.

8. Specific Human Factors Research Requirements within USACDCCSG and Assigned Agencies. Actually, there are two ways which may be used by CSG and its assigned agencies when there are requirements for human factors research:

a. Required research may be requested in accordance with provisions of paragraphs 4, 5, 6, and 7 above, or

b. Required research may be requested through the medium of annual programs solicited by the US Army Behavioral Science Research Laboratory (USABESRL), the Human Resources Research Office (HumRRO), and the Center for Research in Social Systems (CRESS).

The USABESRL is a Class II installation under command of the Chief of Research and Development. Their mission is to accomplish research in personnel measurement, classification, selection and utilization directed toward optimal employment of Army personnel

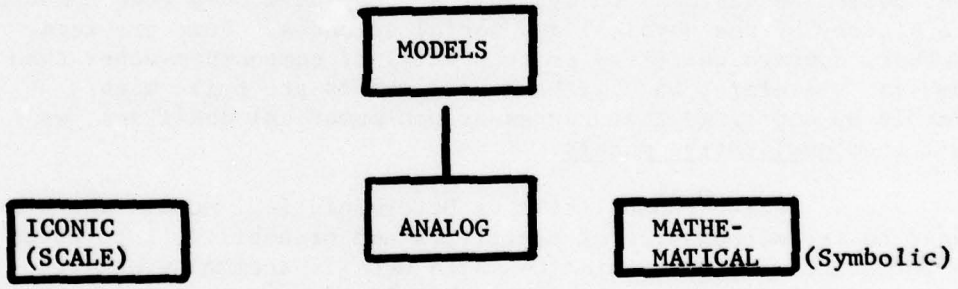
in a variety of military settings. The HumRRO is a contract agency (and, therefore. subject to change, depending upon contractual procedures) under direct supervision of the Chief of Research and Development. They are responsible for conducting studies and research in training, motivation, and leadership. CRESS, also a contract agency (also subject to renewal or termination of contract) under direct supervision of the Chief of Research and Development, is responsible for the conduct of non-materiel research to support the Army mission in fields such as counterinsurgency, unconventional warfare, psychological operations, and military assistance programs. Each year (generally, during the October, November, December quarter), USABESRL will circulate their on-going and projected work programs for review and submittal of related requirements and/or essential input. Each such annual program will be disseminated sufficiently in advance to permit HQ, CSG and subordinate agencies to relate it, where appropriate, to needed CSG research.

CHAPTER XI

MODELS

1. Models Defined.

a. General. Part I of the Methodology Notebook defines a model as "qualitative or quantitative representation of system or process or environment in a mathematical or physical form which is suitable for examining the way the system or process behaves... Models do not represent the actual phenomena of reality in all respects; they must be carefully designed to represent well enough the inputs, internal characteristics, and outputs that are essential for the purpose of which the model is developed." Part I classifies models into three basic types: Iconic (which is frequently called "Scale"), Analog, and Symbolic. Model classification is shown below:



Aero Dynamic	Mech. Model	Hycro Dynamic	Analog Cptr	Digi-tal Cmptr	Invntry	Wait-ing Line	Linear Programming

Of the above, the mathematical form of the symbolic model is the most prevalent type used in OR. The mathematical model is the most sophisticated of the model family. It has the greatest predictive capability and is capable of exact optimization techniques. Once the mathematical model has been formulated, it can be manipulated to examine any of the variables of parameters included within the mathematical model and through this manipulation allow the observer to examine the behavior of any of the factors represented. This capability carries with it the implication that once the mathematical model has been formulated, additional information about the real-world system cannot be introduced without re-building the mathematical model. The use of random numbers in stochastic

processes helps to limit the restrictions implied. As such, the mathematical model remains the first goal of the builder's attempt to create a replica of a real-world system.

b. Types of Mathematical Models. The CSG and agency action officer must be familiar with the various types of mathematical models. Knowledge of the types and how each function will enable him to fit the model to the job to be done and will provide him with the invaluable analytical ability that is so vitally essential in the review of contractual research studies. For ease of assimilation, the models are described below and in Figure 1 from a comparative point of view.

(1) Quantitative vs Qualitative. Basically, the research analyst must decide whether the principal symbols of a model indicate numbers or something else. In many problem situations, the numerical or quantitative aspects of the various components of the problem are the most important. When a mathematical model is built and is translated into symbols for constants and variables which, for the most part, stand for numbers, it is called a quantitative model. These are by far the most common in business today, just as they have been down through the history of the physical and social sciences. Some problems, however, concern qualities or properties of components other than numbers, therefore, when mathematical models are built with symbols by and large that represent non-numerical qualities, we call them qualitative models.

(2) Probabilistic vs Deterministic. Models which are based on the mathematics of statistics and probability into which is introduced the uncertainties which usually accompany observations of real events are called probabilistic models. A quantitative model which does not contain probabilistic considerations is a deterministic model. Such a model permits no uncertainty in the magnitudes of either inputs or outputs. An example from gunnery is:

$W = RM$ where W is the lateral distance at Range R and M is the angular measure in mils of the arc subtended by W at range R. For any set of given values for R and M, there is one and only one value for W. Many deterministic models use an average as a constant value input. The probabilistic model differs from the deterministic in that the probabilistic makes allowances for randomness in one or more of the factors that determine the outputs of the model. For example, an inventory model that optimizes an inventory policy to avoid inventory shortages is probabilistic if it takes explicit account of uncertainty over a period of time in the distribution of demands on the inventory. The model would be determinstic if it assumed that the rate of demand against the inventory is always the same (usually the

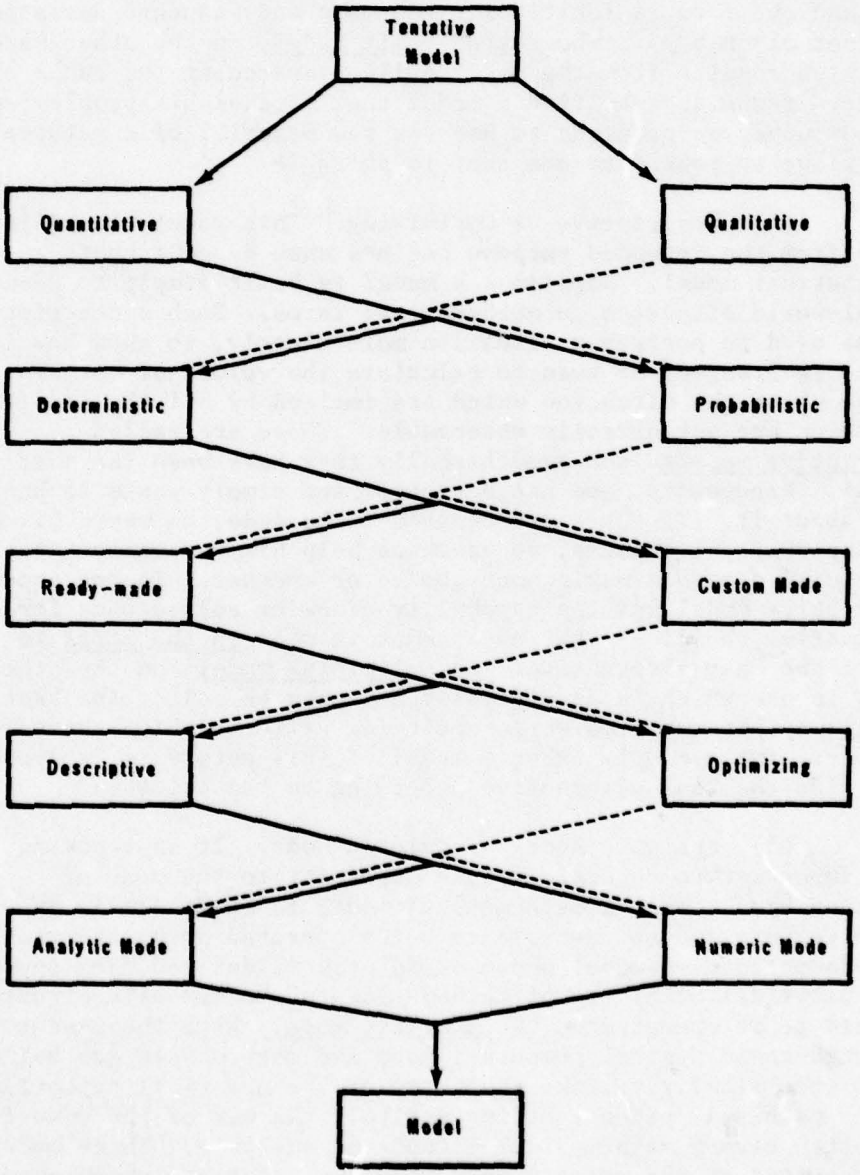
estimated average demand). In this example, a deterministic model would most probably give answers that would lead to bad inventory policies.

(3) Ready-made vs Custom Built. The term ready-made model denotes those standard mathematical problem forms which are taught in schools as "techniques" in which one needs only to insert his own set of numbers to get a ready-made answer to his problem. Examples are the formula for finding the equation of a regression line and the formula for finding the mean and standard deviation of a set of numbers. The custom-built model, on the other hand, is one which results from the model builder searching the range of standard techniques to find a model that matches his problem and, finding none, he proceeds to use the raw material of a mathematical descipline to fabricate one that is suitable.

(4) Descriptive vs Optimizing. This model classification stems from the intended purpose one has when he constructs a mathematical model. Sometimes a model is built simply to describe a real-world situation in mathematical terms. Such a description may be used to portray a situation more clearly, to show how it can be rearranged, or even to calculate the values of certain things about the situation which are implied by all the conditions but which are not directly observable. These are called descriptive models, and traditionally they have been the most useful. Frequently, one has a problem and simply wants to know more about it. If there are choices to be made, he wants his model to display these choices, and perhaps help him by evaluating the consequences of his making one choice or another. In any case, the descriptive model has the capability of being solved once for each alternative choice --- but no attempt is made in the model to select the best alternative. An optimizing model, on the other hand, is one which is specifically designed to select the best among many alternatives while employing criteria which themselves are part of the model. When a model of this nature is "solved", it yields the best alternative according to the criteria.

(5) Analytic Mode vs Numeric Mode. It is becoming more important to separate models according to the mode of solution used. When a mathematical model is built, it is in symbolic form and susceptible to being operated on by the machinery of mathematics. A model whose usefulness is derived from applying the analytical machinery of mathematics to the symbolic structure is said to be operated on the analytic mode. With the advent of the high-speed digital computer, more and more models are being built specifically to take advantage of the numerical capabilities of the machines, often avoiding entirely the use of the powerful but often clumsy mathematical methods of analysis. These models are operated on the numeric mode, and any solutions which they

provide will be numerical in form, rather than in the form of equations, formulae, or mathematical symbols of any kind. In the numeric mode, the focus is on the process of computation which must be explicitly stated to take advantage of the brute strength of the digital computer. In most practical problems, one ends up substituting some particular numerical values for variables in a formula to get numerical answers, even though the model was operated on the analytic mode.

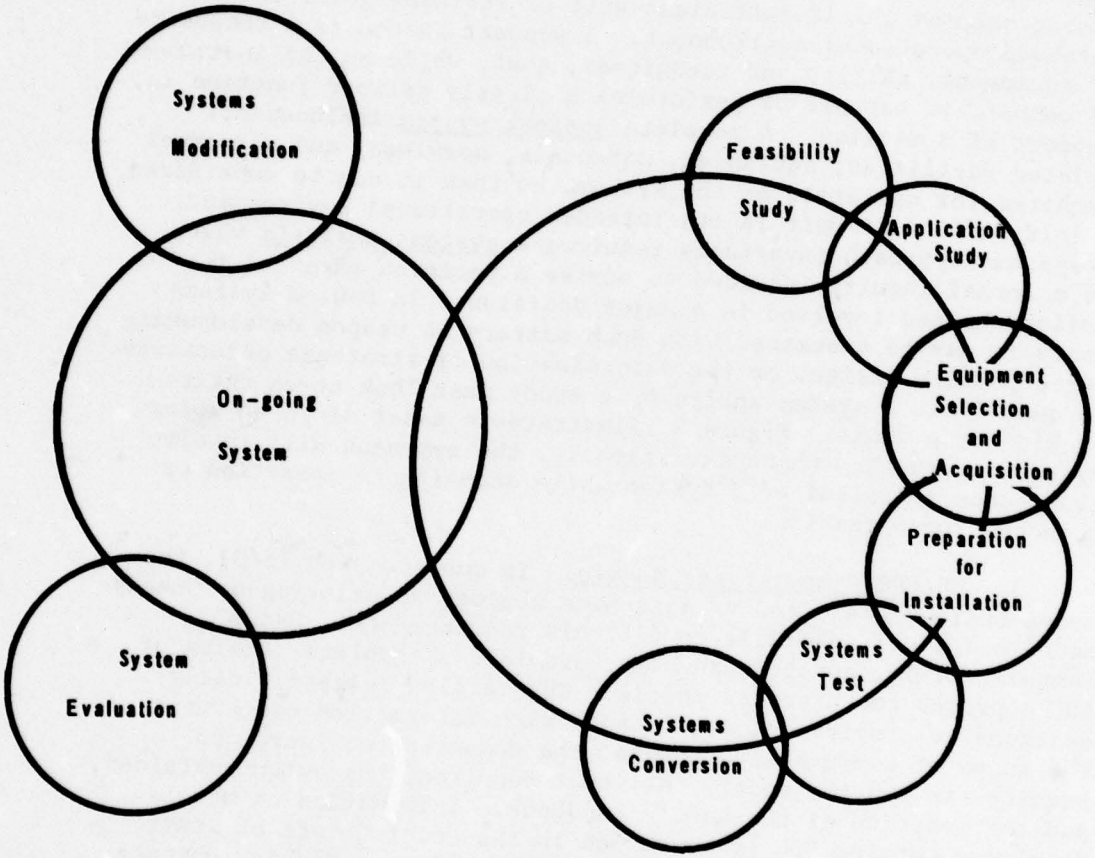


2. The Systems Approach. The systems approach is the determining of objectives of a complete system; segregating the system into sub-systems; drafting objectives for each sub-system; examining the system to insure that no significant interface has been omitted; and hypothesizing of ways to select the optimum means for producing the desired output. A system is composed of equipment, skills, and techniques, the composite of which, in combat development language, forms an instrument of combat. A complete system includes all related facilities, equipment, materials, services, and personnel required solely for its operation, so that the instrument of combat becomes a self-sufficient unit of striking power in its intended operational environment. A support system is a composite of equipment, skills, and techniques, that, while not an instrument of combat, is capable of performing a clearly defined function in support of a mission. A complete support system includes all related facilities, equipment, materials, services, and personnel required for operation of the system, so that it can be considered a self-sufficient unit in its intended operational environment. A systems approach invariably requires a systems analysis which is a formal inquiry intended to advise a decision maker on the policy choices involved in a major decision. In DoD, a systems analysis may be concerned with such matters as weapon development, force posture design, or the determination of strategic objectives. To qualify as a system analysis, a study must look at an entire problem as a whole. Figure 2 illustrates a model of an on-going systems approach. Characteristically, the approach will involve continuous appraisal of a system while actually in operation or proposed for operation.

3. USACDC Computerized Models. In subparagraph 1b(3), the model builder was urged to determine whether an existing or "ready-made" model was available to fill his requirements. USACDC Pamphlet 71-11, updated annually, provides a complete catalog of CDC approved computerized models. The catalog is specifically designed to provide potential users with information concerning the scope of computerized models, the computer configuration required to run the model, the input required, the output obtained, and the location of the user's handbook. Information on models developed outside CDC is contained in the Joint Chiefs of Staff, Joint War Games Agency, the Catalog of War Gaming Models, Defense Documentation Center, AD No. 806-500.

4. Model Characteristics.

a. Resume' of Requirements. To assist the CSG or Agency Action Officer who must build his own model or review for adequacy, the models of others, a resume' of the important model characteristics has been compiled. These characteristics are included herein for use as appropriate.



THE SYSTEMS APPROACH

FIGURE 2

(1) General. It is desired that the model be two-sided and employ both deterministic and Monte Carlo techniques as appropriate. The simulation should allow for intervention of human judgment when it is necessary to insure valid and consistent outputs -- for example, a stop-point to allow military analysts to examine the selection of conditional tactics of deployment. The model should be sufficiently divisible by sub-routine to allow for the exclusion of unnecessary, overly complicating detail not required in a specific evaluation.

(2) Numerical Limitations. It is highly desirable that the simulation technique employed not numerically limit the number of players, number of units, type weapons and their associated munitions, etc. When a numerical limitation must be accepted, it is imperative that it be large enough so that it will not impose a restriction on the usefulness of the model. It is recognized that computer capabilities establish certain limitations which cannot be overcome.

(3) Combat Arms Units. The model must play maneuver elements of the combat arms at brigade level and below. The smallest element need not be the individual soldier but should represent the basic maneuver (squad) and fire support (crew served weapon) elements of the combat arms being simulated. When the simulation is being run at company level and below, it is highly desirable that the individual soldier and combat vehicle be represented. Artillery and aviation units must be depicted so that an evaluation can be made of divisional and force elements as they affect the outcome of bragade level and below combat.

(4) Output. The model must allow the user to select appropriate portions of the total information available. Maps, charts, graphs, and machine printouts must be in a format usable by the average combat arms officer with out a technical background in computer simulations.

(5) Battlefield Size. The size of the battlefield represented by the simulation must be compatible with the areas of influence and effect of the maneuver elements and their supporting arms. It is highly desirable that the micro-terrain be represented by a scroll technique which would not place a numerical limit on the battlefield size. Micro-terrain features must be appropriate to smallest combat elements represented and include an appreciation of cover, concealment, and terminal weapons effects.

(6) Mobility. The quality or capability of military forces which permits them to move from place to place while retaining the ability to fulfill their primary mission includes the means of movement by ground, air, or water. Inherent in this

definition is the desired capability to portray dynamic situations in the simulations. Consideration must include the effects of terrain, weather, maneuver, rates of movement, unit mission, darkness and degraded visibility, degradation of materiel, barriers, obstacles, enemy fires, and equipment characteristics. Tactical variance for mobility should be instilled for main attack, supporting attack, defensive or retrograde movements. It is highly desirable that individual-type vehicle mobility should be measured as a function of limiting acceleration, deceleration, and interaction with soil and grade angle. Considerations should also be given to mines, obstacles, barriers, friendly fires, and other measures employed to deny enemy mobility.

(7) Maneuver. The model should have the capability of selecting various avenues of approach, routes of advance, and techniques of movement for units and vehicles as a result of terrain, tactical options, and friendly and enemy fires.

(8) Firepower. The model must simulate the capability for reducing the combat potential of enemy and friendly forces by physical destruction of their resources. It should include all types of organic firepower, support, and those weapons systems or other means by which the effectiveness of enemy firepower is reduced. The effectiveness and availability of firepower on the tactical battlefield is a function of type terrain, composition of enemy forces, rates of fire, intelligence, command, communications, equipment characteristics, resupply, cover, weather, personnel and equipment vulnerability, field fortifications, tactical air support, and other elements of combat.

(9) Effects of Artillery Fires. The model must be able to measure the effects of various combinations of artillery weapon systems and munitions against personnel and materiel targets. In addition, it must provide a measure of the capability of artillery systems or combinations thereof to deliver harrassment and interdiction fires, illumination, barriers, preparations, counter-preparations, final protective fires, smoke and other special missions. The capability for evaluation of effects of high explosive, special, and nuclear munitions must be included. A capability for evaluation of chemical and biological munitions is desired. Effects must include casualties and/or damage achieved, missions accomplished, and missions not accomplished according to established criteria. Efforts required to accomplish the established criteria in terms of cost and weight of ammunition must be part of model output. Capability for evaluation of artillery fires under "surge" conditions is also required. Capability for evaluating requirements for number of tubes or launchers per battery and/or battalion should be included. Necessary interface with other firepower means must be included in order to determine realistic artillery firing requirements.

(10) Effects of Tank/Antitank Weapons. The purpose of a routine to determine the effects of tank, antitank, and assault weapons separately or in varying combinations is predicated on a determination of the firepower performance capabilities of direct fire weapon systems which could feasibly be developed within the state-of-the-art of the time frame. This routine or model should provide values which reflect the effectiveness of the firing weapon against the target. The model should be sensitive to effects variations depending upon the firing weapon, projectile, and target type should be able to play the suppressive effects on targets not actually hit. This process may be deterministic or Monte Carlo in approach. In summary, the tank, antitank, and assault weapons effects model should consider most of the factors applied to the probability of obtaining a hit on a target, using the variables of the round fired, the firing vehicle moving, the dimensions of the target and the configuration of the target. This requirement is further expanded to include interaction among indirect fire weapons, mines, and aerial systems.

(11) Effects of Direct Fire Infantry Weapons. The model must be able to measure the casualty producing and suppressive effects on targets (troops, materiel, and equipment) from the fires of all direct fire infantry weapons. The model must also provide for the ability of rifle units, automatic weapons teams, and direct weapons teams to locate and identify enemy targets. The model must discriminate and be sensitive to definitive changes in range and probabilities of hits.

(12) Effects of Mortars and Other Indirect Fire Weapons. The model must be able to measure the effects of various combinations of mortars and other indirect fire weapons and ammunitions against targets to include personnel, materiel, and equipment. In addition, a measure of the capability of these systems or mixes to deliver "other fires" in support of maneuver forces must be included. Necessary interaction with other firepower means must be included in order to determine realistic firing requirements for mortars and other indirect fire weapons. Effects must include casualties and/or damage achieved, missions accomplished, and missions not accomplished according to established criteria. Efforts required to accomplish the established criteria in terms of cost and weight of ammunition must be part of output.

(13) Tactical Air Support. The model must include the play of tactical air support to the extent required to evaluate its effects upon the requirements for other direct and indirect fire support means.

(14) Effects of Nuclear, Chemical, and Biological

Weapons. For other than artillery fires, it is desired that the model be capable of simulating the effects of nuclear, chemical, and biological munitions, in conjunction with conventional munitions, against targets and target complexes found on the battlefield. Consideration should include immediate and residual effects of these munitions.

(15) Command. The model should accept a variety of missions and decision rules to include orders and priorities.

(16) Communications. The model should simulate communications factors such as transmission times, time delays, or lack of communication.

(17) Air Defense. The model must include the effects of air defense weapons and other direct fire weapons upon the outcome of Army airmobile operations. It is desired that the model include an appreciation of the restrictions placed upon maneuver and fire support resulting from the lack of air defense.

(18) Equipment Characteristics. The model should accept as inputs variations in critical characteristics of mission essential equipment (other than weapons) with the intended purpose of comparing like vehicle types and assessing the impact of other equipments on the battlefield. For example, the ability to simulate different speeds for take-off, climb, cruise, dash and landing, all on the same flight, is required.

(19) Weapon Description. The model must accept as input items the hardware characteristics of the weapon systems to be played in the computerized simulation. Military characteristics such as speed, acceleration, cruising range, fording depth, ballistic protection, combat load, reliability are characteristics which may apply to the weapon system in general. Other characteristics such as time to detect targets, time to fire first and subsequent rounds, rate of fire, hit probability, range and accuracy, and projectile effectiveness or reliability apply to the weapon system, its fire control, and possibly the gunner's ability to successfully engage a target under quasi-combat conditions. Comparable inputs are required for munitions.

(20) Terrain. As a minimum, the model must accept elevations, trafficability, cover, and concealment indices and compute their effects on rates of movement and intervisibilities.

(21) Weather. The model should accept varying ceilings, visibilities, temperature, and precipitation and realistically measure their effects on rates of movement and intervisibilities.

(22) Rules of Engagement. The model must accept rules pertaining to ranges of opening fire, massing criteria, rates, direction, duration of fire, priorities of fire, and levels of fire direction as determined by unit mission. Rules of engagement will be closely tied with unit defeat and success criteria and weapons capabilities. The model or appropriate subroutines must be capable of accepting a variety of engagement rules so as to realistically depict tactical play required by various combat elements.

(23) Personnel Vulnerability. The model must accommodate single round and burst kill probabilities or suppression on personnel under varying degrees of exposure for all types of weapons available to game forces.

(24) Intelligence. The model must consider the impact of intelligence upon the selection of courses of action. The detail to which this is played will be dependent upon the information available in the data collection and evaluation area.

(25) Target Acquisition. The process and procedures for detection, identification, and location of targets in sufficient detail to permit the effective employment of weapons. Consideration must include the effects of terrain, weather, cover, concealment, intelligence, ground reconnaissance and surveillance, air reconnaissance and surveillance, communications, intervisibility, target response/location/identification, effects of darkness/degraded visibility, effects of night illumination and night vision, effects of laser illumination, degradation of materiel, electronic warfare equipment characteristics, rates and direction of ground movement, and maneuver.

(26) Unit Effectiveness to Include Unit Break and Defeat Criteria. The model must accept or establish a break-point where a unit's cumulative losses or casualties render it incapable of accomplishing its original mission. It will measure various forms of destruction, attrition, or partial loss, to establish effectiveness rates and percentages for continued operations for different size units and missions. This may take the form of change of mission, narrowing of zone, or use of other means of firepower or maneuver. Effects of interaction between various firepower means must be included.

(27) Suppression/Neutralization/Destruction. The model must be able to determine the capability of various weapons, weapon system and munitions combinations of suppressing, neutralizing, and destroying the targets and target elements found on the battlefield according to specific criteria.

(28) Survivability. The model should be able to accommodate input factors related to mobility, target acquisition, rules of engagement, intervisibility, various weapon system effects, and personnel and equipment vulnerabilities, and compute overall survivability or attrition of personnel and equipment.

(29) Ammunition Expenditures. The model should tabulate rounds expended by type weapon and ammunition.

b. Use of Existing Models. It may become apparent in the process of examining a model for the characteristics noted in "a" above, that the problem is not new. Chances are that a thorough search of available literature will indeed reveal the previously mentioned "made-to'order" model. Action officers are encouraged to make exhaustive studies for suitable existing models to preclude excessive waste of time, money, and manpower.

CHAPTER XII

RESEARCH WARGAMES

1. General. Chapter V of Part I to the Methodology Notebook contains an excellent overview of Research War Games as they are employed within USACDC. It discusses the types of war games; their role in combat developments; the organization of a war gaming facility; the structure of a war gaming study; the planning, pregame, and play phases; the analysis phase; and the advantages and disadvantages of the player participation war game. Although Chapter V is comprehensive and contains a wealth of "need-to-know" information for the individual action officer, it is more applicable to the experienced officer than to one who is a novice in the war game art. For the benefit of the action officer who is exposed to war gaming for the first time, the ensuing chapter breaks the action down into more definitive terms that are designed to supplement (not replace) the information contained in Chapter V of Part I.

a. Background of Games as an Analytical Technique. A game occurs when each participant in a situation has an objective which may or may not coincide with the objectives of other participants, and when each of the participants controls some, but not all, of the controllable variables of the action and the outputs. In principle, most if not all human activity is gamelike. Even when the action of military personnel is programmed in terms of a common objective, not all of their individual activities may be fully specified by the resulting program; they may consequently find game opportunities on the side. Conflict between opposing military forces is the outstanding instance of a game. The French mathematician Borel noted the quantitative aspects of games in the early 1920's, including the distinction between pure and mixed strategies. The first general theory is due to von Neumann who proved the minimax theorem. The Theory of Games and Economic Behavior, co-authored by von Neumann and O. Morgenstern, was an historic volume which established the subject without stressing its military applications. Much of the military application has been developed under the sponsorship of the Rand Corporation since World War II. Most of what has been developed has far-reaching applications, extending into every phase of military operations. While games may be played involving more than two contestants, only two-person games are considered here.

b. Types of Two-Person Games. Games may be generally

classified into: (1) Matrix Single Game, (2) Allocation Game, or (3) Sequential Game.

(1) Matrix Single Game. This type of game occurs when the contestants each must choose one of a discrete set of alternatives or strategies. As an example, let us suppose that the commander of the Blue forces must choose one from a number of possible routes to pass through an area defended by Red. Red, in turn, can defend only one route. It is obvious that the "payoff" to Blue will be greater if the route he selects is not the same as the one that Red has selected to defend. The payoff for any choice of route also may be influenced by such factors as the length of the route or obstacles to movement. The joint choice of moves or strategies by Blue and Red can be represented by a square matrix in which V_{ij} is the payoff to Blue if he chooses Route i ($i = 1,\ldots,n$) and Red chooses to defend Route j ($j = 1,\ldots,n$). It should be noted that the payoff to Blue can, in some cases, have negative values.

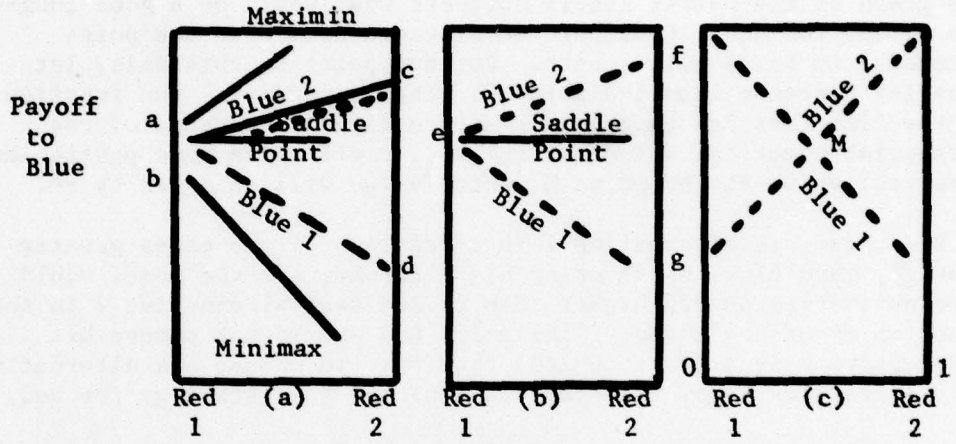
(2) Allocation Game. In the allocation game, each opponent may simultaneously allocate his forces (or other resources) among more than one course of action. For example, Blue can attack a Red force, from either of two directions, or, by dividing his force, can attack from both directions. Red knows the directions and has the option of dividing his force so as to defend in both directions. If Blue allocates x units to direction 1 and Red allocates y units to direction 1, then the payoff to Blue (or loss to Red), v(x,y), may be evident to both opponents. Similarly, for other allocations, the payoffs may be known, and Red and Blue will each select a strategy. If Red's defensive design must be established first, and will become known to Blue, the game is the <u>minorant</u> type. If both sides must allocate simultaneously in ignorance of the other's allocation, the game is the <u>majorant</u> type.

(3) Sequential Game. The most complex type of two-person game is one in which there is a sequence or continuum of strategies to be followed by each opponent. Pursuit, evasion, and continued conflict are typified by this type of game. Differential games are also included in this category. Sequential games will not be discussed in this chapter.

c. Solution to Game Problems.

(1) Graphic Solution of a 2 x 2 Matrix Single Game. Suppose that Blue is capable of successfully defending either of two of his installations but not both. Blue then has two "pure" strategies, Blue 1 and Blue 2, corresponding to the number of the installation he decides to defend. Red is capable of attacking

either installation, but not both, and will also have two strategies. Three general types of this 2 x 2 game situation are shown in the figure below:



Case (a). In this case, the minimum payoff to Blue is at point "d" if he follows his strategy 1 and at point "a" if he follows strategy 2. The maximum of the minimum payoffs (maximin) is at point "a". As for Red, the maximum payoff he must give is at point "a" if he follows his Strategy 1 and at point "c" if he follows Strategy 2. The minimum of his maximum payoffs to Blue (the minimax) is at point "a". When the maximin and the minimax are at the same point, this is called the "saddle point" of the game, and represents the best strategy for both Blue and Red. Blue's Strategy 2 is a "dominant Strategy"; i.e., no matter what Red does, this strategy always has a greater payoff than Strategy 1.

Case (b). This is not different from Case (a), except that if Red uses Strategy 1, it will make no difference what strategy Blue employs. The point "e" now represents a saddle point.

Case (c). This case is the only difficult one to decide. It is the more likely case in practice since it is typically better for Blue to have defended the installation that Red chooses to attack. For Case (c) a policy is needed. Suppose that Blue and Red are individual units or armies that will engage in repeated games with each other. Very likely, a number of these repetitions might consist in (other) games in which the payoff relationships were numerically like (c). If so, then each would gradually acquire knowledge of the other's strategy. For example, if Blue always defended the more valuable installation, this would gradually become apparent to Red.

One way to investigate the question of the best strategy, therefore, is to suppose that this particular game is played over and over. On repetitions of the game, it is not always necessary for either player to make the same choice every time. The figure indicates that it would be better for each to vary his choice.

The graph of the matrix itself suggests what would be a good long-run policy for Red. Consider the distance from 0 to the point labeled 1 to be of unit length. For any point on this axis, let r be its distance from the point 0. Then regard r as the fraction of the time that Red chooses his alternative 2. Because of the particular numerical values of the V_{ij}, r will have some particular numerical value at the point M, which value will be noted by r*.

If Red chose his alternative 2 in a fraction of the cases greater than r*, then Blue, by favoring his alternative 2 the more, would have an average payoff higher than if Red used alternative 2 in the fraction r* of the cases. Similarly, Red should not choose his alternative 2 in a fraction less than r*. To choose his alternative 2 in a fraction r* of the plays is thus the best strategy for Red.

The strategy is termed a mixed strategy; and a problem is how to achieve the mixture in fact over a period of time. One solution is to randomize the choice on each play of the game, setting the probability of choosing R_2 at r.

An exactly similar reasoning will establish the fact that Blue should also use a mixed strategy. A separate figure showing the argument above for Blue instead of for Red may be visualized.

(2) Numerical Solution of a 2 x 2 Game. As a numerical illustration, suppose that installation 1 is worth three times as much to Blue as is 2. Then the solution obtained by applying the above procedure is as follows:

	Red		Row Minimum	Blue's Use Probabilities
	1	2	3	3/4
Blue 1	4	3		
2	1	4		
Column Max	4	4	1	1/4

Red's Use Probabilities:
1/4 3/4

The value of the game is the average payoff to Blue if both opponents use their best strategies. If there is a saddle point, the value of the game is the value of this point.

In case of a mixed strategy, the value is determined by calculating the payoff for either the Red or Blue mixed strategy against either of the opponent's pure strategies. Thus, using Blue's mixed strategy against Red Strategy 2, the value of the game is determined to be

$$\frac{3(3) + 1(4)}{4} = 3.25$$

(3) Graphical Solution of a 2 x m Game. When one opponent has only two choices, but the other has m possible choices ($m \geq 2$), the game becomes a 2 x m game. A graphical method is useful in evaluating the m alternatives so that all but two are eliminated, and the problem is reduced to a 2 x 2 game.

Assume the following matrix of payoffs to Blue:

		Red Strategies (j)			
		1	2	3	4
Blue Strategies	1	-4	7	3	-5
	2	3	-4	2	6

These values are plotted as shown in paragraph 12c(1).

The lowest linear path represents the minimum payoff to Blue for any Red strategy. Of the lines that make up this path, the two that intersect at the maximum value (labeled M on the chart), are the two strategies (in this case, 1 and 2) that should be followed by Red.

Considering only these two strategies, there is now a 2 x 2 game, from which we can proceed to determine best pure strategy (if there is a saddle point) or mixed strategy. See Figure 1.

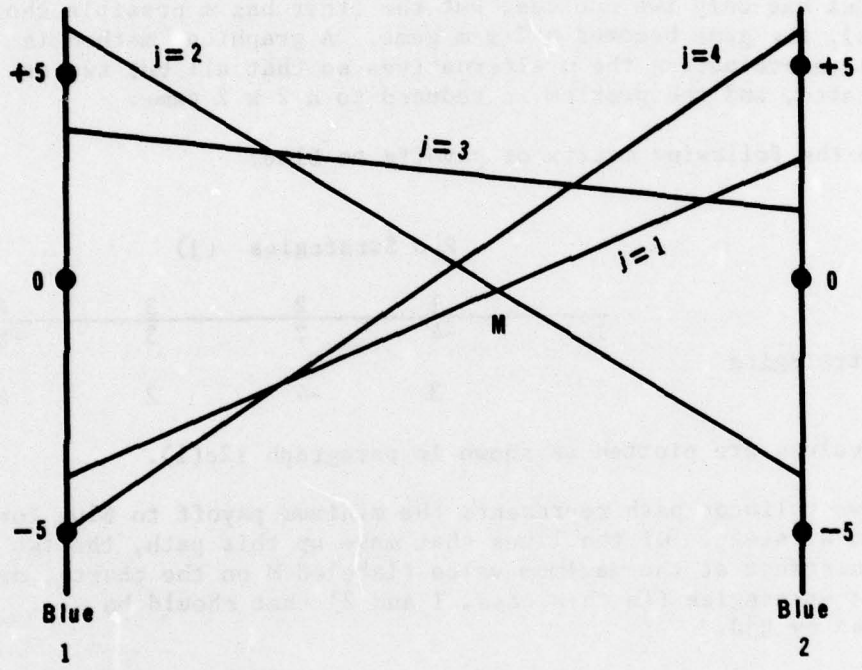


FIGURE 1

(4) Basic Relationships in Determining the Value of a Game. If Blue plays his strategy 1 with probability b and if Red plays his strategy 1 with probability r, then the value V(b,r) of the game will be $V(b,r) = br_{11} + b(1 - r)rv_{21} = (1 - b)(1 - r)v_{22}$.

This can be put into the standard form $V(b,r) = -A(b - b^*)(r - r^*) + V(b^*,r^*)$ where A is a constant. This shows that for all b and r,

$$V(b,r^*) \quad V^* = V(b^*,r^*) \quad V(b^*,r).$$

Identifying coefficients,

$$A = v_{11} - v_{12} + v_{22} - v_{21} \quad \left.\begin{array}{l} \\ \end{array}\right) \quad \begin{array}{l} b^* = (v_{22} - v_{21})/A \\ r^* = (v_{22} - v_{12})/A \end{array}$$

$$V^* = V(b^*,r^*) = \frac{v_{11}\,v_{22} - v_{12}\,v_{21}}{A} = \frac{/P/}{A}$$

where /P/ is the determinant of a payoff matrix.

2. Two examples can be cited from World War II records of how military situations that required a critical decision as to the disposition of forces and assignment of missions developed into the essence of a game.

a. In the Pacific campaign in February 1943, intelligence reports indicated that a Japanese (red) convoy would soon go from Rabaul at the east end of New Britain on the mainland of New Guinea. The convoy would have a choice of two routes, each requiring about three days of sailing. One route was the north coast of New Britain, for which bad weather was forecast for the first two days. The other was the south coast, for which the forecast was for clear weather. The US Air Force Command (Blue) was ordered to intercept and inflict as much damage as possible on the convoy. Blue's choices were between which of the two routes to concentrate most of his reconnaissance aircraft. Once the Red convoy was spotted, on either route, bombers could strike it.

The Blue Commander estimated that the following outcomes would occur:

	Red North	Red South	Row Min
Blue North	Convoy would be discovered by the 2d day, permitting an estimated <u>two days of bombing</u>.	Convoy would be dis-dovered by the 2d day permitting an estimated <u>two days of bombing</u>.	2
Blue South	Convoy would be discovered on the 3d day, permitting <u>one day of bombing</u>.	Convoy would be discovered immediately, permitting <u>three days</u> of bombing.	1
Col Max	2		

Using days of bombing as the measure of payoff, we have a 2x2 game in which there is a saddle point (Red North, Blue North), with a value of the game of two days of bombing.

In fact, Blue and Red selected these strategies. In the book, <u>Military Decision and Game Theory</u>, the author, O.G. Haywood, Jr., points out that the game was correctly considered to be zero-sum game, since the outcome judged good by one commander was judged bad by the other in corresponding amounts.

b. According to General Bradley's report, the following situation developed when the Allied (Blue) had just broken out of their beachhead on the French coast through a narrow gap by the sea of Avranches, exposing the west flank of the German 9th Army (Red). This Army was already being contained by a frontal attack by the US 1st Army Red had two choices: (1) attack westward and try to cut off the gap; or (2) withdraw substantially eastward to a better defensive position. Blue's key decision concerned what to do with an uncommitted reserve of four divisions located just south of the gap. Three mutually exclusive courses of action were considered: (1) order the reserve back to defend the gap; or (2) send the reserve eastward to press Red; (3) wait one day. Blue estimated that if Red attacked but the gap held for one day, later reinforcement would be unnecessary.

The probable outcomes are not quantitatively as simple as those in example (1) above. Bradley develops them at some length (with no explicit reference to game theory or its terminology) pointing out the importance, as events subsequently proved, of the decision to the Red force. The row minima are:

for Blue (1), the gap is not cut

for Blue (2), the gap is cut

for Blue (3), weak pressure on Red's withdrawal, gap may be cut

The colume maxima are:

for Red (1), the gap is not cut and Red may be defeated

for Red (2), strong pressure on Red withdrawal

General Bradley (Blue) adopted course of action (1), the maximin. The German (Red) Commander (von Kluge) is reported to have adopted course of action (2), the minimax, but to have been countermanded by Hitler. The German Army attacked westward and was badly defeated; von Kluge subsequently committed suicide.

CHAPTER XIII

AUTOMATIC DATA PROCESSING EQUIPMENT

1. General. With the rapid advance in technology and the correspondingly increased requirements for rapid assimulation of data, there has been a stadily increasing demand for automation of management information systems. This requirement has exhibited itself within CDC in recent years in an ever rising crescendo. Practically every major project now requires automatic processing of data. To meet these requirements on a timely basis, DA and Headquarters, USACDC have published a series of regulatory documents. Some of these documents are not generally applicable at the Headquarters, CSG, and agency operating levels; however, some are vitally applicable. They are as follows:

a. AR 18-1, 14 February 1966, "Army Information and Data Systems - Objectives and Policies".

b. AR 18-2, September 1967, "Army Information and Data Systems - Responsibilities and Procedures".

c. TB 18-7, April 1966, "Army Information and Data Systems".

d. AR 705-5, 15 October 1964, "Army Research and Development".

e. Letter, CDCCM-DPSA, Headquarters, USACDC, 12 June 1967, "Operating Procedures, US Army Combat Developments Command Data Processing Installation - Fort Leavenworth".

2. ADPE Defined. ADPE includes:

a. Electronic digital computers and hybrid in conjunction with or independent of an electronic digital computer.

b. Punched card machines (PCM) used in computers irrespective of use, size, capacity, or price.

c. Peripheral or auxiliary equipment used in support of an electronic digital computer or PCM whether used on-line or off-line and whether selected or acquired with the computer or PCM or separately.

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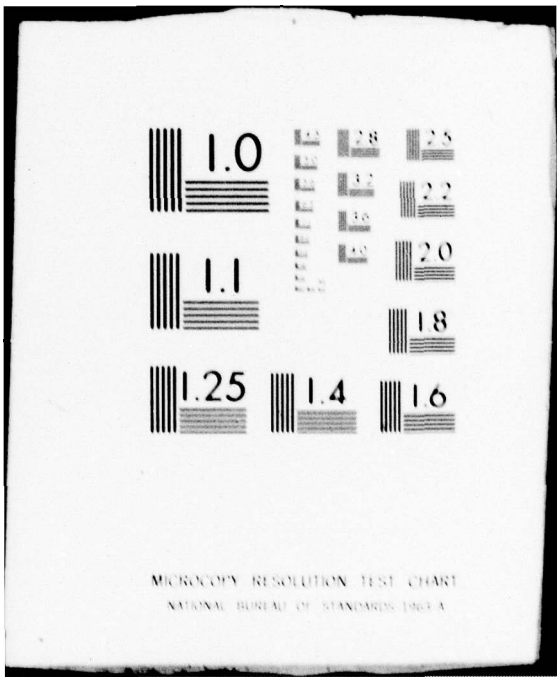
1.0
1.1
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2.0
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

d. Data transmission and communications equipment that is selected and acquired solely or primarily for use with a configuration of ADPE.

3. USACDC ADPE Procurement and Management Policies. All CDC procurement and management is centrally controlled. That is, the CDC comptroller is the final approving authority on all requests for ADP actions, for providing approved ADP services, for establishing priorities among competing CDC requirements, and for scheduling computer runs. The comptroller provides these functions through an ADP advisor in his office (telephone extension 46824). To provide the necessary ADP services, he observes certain DA policies and procedures guidelines and regulations which are listed below:

a. Central control, in this case, also means centralized computer services. This centralization is accomplished by locating the USACDC Data Processing Field Office at Fort Leavenworth, Kansas, where an Army-owned Control Data Corporation 3300 is established for the purpose of fulfilling all USACDC ADP requirements that do not exceed 3300 capabilities.

b. Determining sources for fulfilling ADP requirements. Basically, there are four sources that the comptroller may use, depending upon the nature of the particular requirement:

(1) First, he is required to utilize the Army-owned CDC 3300 computer if it has unused time available and is capable of performing the job.

(2) If, for justifiable reasons the CDC 3300 cannot be used, he is required to submit his request to General Services Administration for utilization of other government-owned ADP facilities.

(3) If, for valid reasons, the use of other government ADP facilities is impractical, he may lease or rent ADPE from non-government sources, but not unless ADPE utilization screening procedures as outlined in AR 18-4 have established that suitable government equipment is not available to satisfy the requirement.

(4) If required computer services are less than $10,000 per contract, he may purchase the necessary computer time. Contracting for services through a series of incremental-type contractual arrangements involving more than one contract of $10,000 or less, none of which provide a completed project is prohibited.

4. ADP contracts as separate entities for group or agency convenience are prohibited. A request for ADP services is not

considered unless the requested service is a necessary part of an approved project. Headquarters, CSG or assigned agencies are not authorized to request computer time for the purpose of convenience or for consolidating several non-related projects.

5. Software Policies. COBOL is the Department of the Army standard computer language for use in business-type automated information and data systems. Within CDC, the computer language used for scientific research will be Formula Translation IV (FORTRAN IV).

6. The CDC 3300. As previously mentioned, the USACDC Data Processing Field Office is at Fort Leavenworth, Kansas; its operational control is at Headquarters, USACDC. The office functions as a data service center bureau under the operational control of the comptroller, HQ, USACDC. Computer operating services are furnished for both contractors and command personnel engaged in approved combat developments activities. To obtain time on the CDC 3300 computer, the using agency should notify the CDC Office of the Comptroller through channels. As a minimum, the notification must include:

a. Applicable action control numbers.

b. Study or project directive.

c. Study or project title.

d. Contractor(s), if applicable.

e. USACDC Proponent Activity.

f. Approximately required number of computer usage hours, by month.

g. Data application must be complete, if applicable.

h. Model or simulation to be employed.

7. Scheduling the CDC 3300. Based on known projected operating support requirements, the Comptroller, HQ, USACDC, will determine the availability of unused computer time and will advise the CDC activity as follows:

a. Time is available on the 3300 for the hours of use and time period requested. Arrangements for daily use may then

be undertaken directly with the Officer-in-Charge, Fort Leavenworth Division, USACDC Data Processing Field Office.

b. Insufficient unused 3300 time exists. Alternate sources of acquiring the time will be explored by the comptroller under the provisions of AR 18-4 and the activity concerned will be advised of the alternate source of computer support.

8. Processing Priorities. As necessary, for studies and projects supported by the CDC 3300, Headquarters, USACDC may establish processing priorities. Priorities will be assigned to specific studies or projects and will be the result of Headquarters, USACDC Command Group decisions.

9. Telephone Contact. Subject to staffing by CDC, daily use of the 3300 computer (once a priority has been issued) may be undertaken by direct contact between the CDC activity and the OIC, Fort Leavenworth Division, USACDC Data Processing Field Office, Area Code 913, telephone Overland 4-4169. Extended projections and reservations for daily use of the computer will not be honored and should not be solicited. Operating experience to date has proved that firm allocation and reservation of hours of computer use beyond two days from the current date is not practical and results in non-use of computer time which could otherwise have been gainfully employed. The hours of operation of the 3300 is 0800 to 2400 daily including Saturdays and Sundays (496 hours per month). The scheduling of time beyond these hours will require 3 days of advance notification to the Officer-in-Charge.

CHAPTER XIV

THE FIVE-YEAR RESEARCH AND DEVELOPMENT PROGRAM

1. The OR Schedule. In January of each year, Headquarters, USACDC formulates the annual command Five-year schedule for Research and Development. This schedule identifies the scientific support requirement for each agency and institute and provides the necessary supporting data for submission of USACDC requirements to the Office of the Chief of Research and Development (OCRD). The importance of the schedule is obvious. From it, the planning program evolves and the necessary funding is provided for ensuing contractual support during applicable years. Inasmuch as presentation of a meaningful and complete fire-year command schedule can be based only upon inputs from subordinate components of CDC, it is imperative that each subordinate agency of CSG formulate its five-year operations research schedule at least ninety days in advance of the 15 January due date (by 15 October). In like manner, it is essential that CSG consideration and approval of the agency plan be completed not later than 15 December of each year. Although the detailed format for submission of the Five-year R&D Schedule is published annually by Headquarters, CDC, there are certain essential elements of the program which remain constant from year to year. The constants can be used to facilitate timely advanced planning, and, if followed, can produce a high quality end product. The following procedures will apply when agencies submit their five-year schedules to Headquarters, CSG:

a. The base schedule of the previous year will be used as the beginning point for planning purposes. Depending upon the relation of a proposal to the previous base schedule, each proposed action will be identified at the top of the first page as follows:

(1) Category I: Those actions which were in the previous year base schedule, which are using contractual support, and will not be completed by the end of the current fiscal year. (When any change is anticipated in a Category I project, its submittal as part of the five-year OR Plan must be accompanied by a USACDC Form 87 prepared in accordance with Vol 1, USACDC Pamphlet 71-3.

(2) Category II: Those actions which were in the base schedule when the plan was submitted the previous year, but for which contractual support was not obtained during the year, and for which a requirement still exists. (Category II projects must be

accompanied by a USACDC Form 87 reflecting any proposed changes for the following fiscal year or any ensuing year).

(3) Category III: Those actions which were not initially scheduled when plan was submitted the previous year, but which have been authorized contractual support during the year, and which will not be completed by the end of the current fiscal year. (Category III projects must also be accompanied by a USACDC Form 87 reflecting any proposed changes for the following fiscal year or any ensuing year.)

(4) Category IV: Those actions now in the USACDC program which will require contractual support during the following fiscal year and/or subsequent years. (Category IV action requests must be accompanied by a Form 87 as required by paragraph 6, USACDC Regulation 71-6 and a completed Research and Technology Resume, DD Form 1498.)

(5) Category V: Those new items which are proposed to be entered into the USACDC Program and which will require contractual support during the following fiscal year and/or subsequent years. (Category V action requests must be accompanied by a completed Research and Technology Resume, DD Form 1498 and three USACDC Form 87's prepared in accordance with Volume 1, USACDC Pamphlet 71-3, April 1968.

b. Agencies will forward each USACDC Form 87 and DD Form 1498 in triplicate. Instructions for completing Research and Technology Resume, DD Form 1498, 1 August 1964, are as follows:

(1) Items 1, e, and 3 leave blank.

(2) Item 4 enter date of preparation.

(3) Item 5 enter either Old meaning the project is now contracted for and additional support is required in the scheduled year(s) or New which indicates this is the first time the project has been proposed for contractor support.

(4) Items 6, 7, and 8 will be completed in accordance with AR 705-12, Change 3.

(5) Items 9, 10a and 10b leave blank.

(6) Item 11 enter the same title as listed on Inclosure 2.

(7) Item 12 leave blank.

(8) Items 13 and 14 indicate required dates.

(9) Items 15, 16, 17, 19, 20, 21, and 22 leave blank.

(10) Item 18 prior year will be the dollar amount shown in column 7 of Inclosure 2, current year will be the dollar amount shown in column 8, inclosure 2.

(11) Items 23, 24, 25, and 26 complete. Refer to AR 705-12, change 3.

(12) Item 27, Communications Security, complete. Refer to AR 705-12, Change 3.

(13) Items 28, 29, 30, 31, 32, 33, 34, and 36 leave blank.

(14) Item 35, estimated funds, enter here the dollar amount shown in column 9 of Inclosure 2.

2. Preparing the Five-Year Plan. As soon as the Five-Year Plan submitted in any particular fiscal year is approved, agencies should start work on the plan to be submitted for the following fiscal year. The following general guidelines will assist action officers in planning the program:

a. Projects to be included in the Five-year OR Plan will be prepared in accordance with para 2, Chapter XIV of this notebook and with USACDC Pamphlet 71-3.

b. Detailed supporting data is not necessary when the Five-Year Plan is first submitted. (Full details to include statement of work and all supporting data will not be required until after the original proposal has been approved.) The submittal of a proposal as part of the Five-Year Plan will include the following:

(1) A precis of not more than three pages which provides minimum essential information that is thorough enough to permit objective evaluation of the need for the work and at the same time, provide supporting data for funding considerations. The precis will be prepared according to the format in Figure 1.

(2) A precis will be submitted for each project previously approved or anticipated, if the project requires contractual support during the following fiscal year or any part of the ensuing five years.

1. ACTION:

2. NATURE AND SCOPE:

3. NEED:

4. IMPACT OF DISAPPROVAL:

5. BEGINNING & COMPLETION DATES:

6. RECOMMENDED CONTRACTOR:

7.

	FY 70	FY 71	FY 72	FY 73	FY 74
MAN MONTHS					
DOLLARS					

8. ACN NO.

FIGURE I

(3) A USACDC Form 87 in triplicate will accompany Category I, II, and III proposals only if the precis proposes a change in the project. (A change in dollars, scope, time, objective, or any other.) A Form 87 in triplicate will accompany every Category IV and Category V proposal.

(4) Category IV and V proposals will require not only CDC Forms 87 but also DD Forms 1498. Category V proposals are the only ones that may be submitted without Action Control Number.

(5) The costs involved in the Five-Year OR package submitted by each agency will be summarized in the format shown in Figure 2. The following procedure will be used:

(a) Dollar costs for Category I, II, and III items will first be entered identically as they were entered when they were submitted the previous year. Proposed changes for each fiscal year will then be listed directly below in parenthesis. If changes other than in dollars are proposed, an asterisk will be entered after the project title. (The asterisk will alert each reviewer to turn to the appropriate Form 87.)

(b) For Category IV and V items, the estimated dollar costs will be entered in parentheses in the Columns for the applicable fiscal years.

(c) Caution should be exercised in entering estimated dollar amounts. In many cases, present funding will provide contractual support beyond the end of the present fiscal year. If this is the case and no increase is required to complete the support in the following fiscal year, no estimate should be entered in column (9) of the form.

(d) All documents will be in triplicate: the project precis, CDC Form 87, DD Form 1498, project summary.

(e) Each agency will recommend priorities among the project proposals being submitted by that agency as part of the Five-year OR Plan. Priorities will be listed on the summary sheet in Column one identically to the priority established the previous year. Column 2 of the summary sheet will contain the recommended priority for now and subsequent years, without regard to the priority entered in Column 1. Upon receipt of all agency proposals at Headquarters, CSG, an officially appointed committee of action officers and/or division chiefs will evaluate proposals and establish final relative priorities for the entire CSG Five-Year Package.

(f) The Itinerary for the Five-Year Program. The scheduled completion dates* for each phase of the Five-year OR Program are as follows:

1 September to 1 October	A CSG Action Officer visit to each agency to advise agencies on 5-year Plan formulation.
15 October	Completed agency proposals due at HQ, CSG.

22-27 October (five working days)	Formal Agency presentation at HQ, CSG (One agency presentation per day).
15 November	Final agency revisions due at HQ, CSG.
22 November	CSG Division Chief and Action Officer Committee evaluates proposals and establishes CSG priorities.
15 December	Final 5-Year Proposals due at HQ, CDC

*ALL the above dates are dependent, of course, upon their falling within the working day schedule. When any of the above dates in a particular year fall on weekends, the workday next preceding each due date will prevail.

(g) After the entire CSG package has been considered by HQ, USACDC and HQ, CSG has received notification of approval action on any particular proposal, HQ, CSG will then request the proponent agency to provide all details necessary for initiating contractual action. (A detailed proposal, statement of work, any other document needed to "kick off" the project on time.)

(h) Consultants and personal services are not authorized as part of the Five-Year OR Plan. Inasmuch as all such services are difficult if not almost impossible to obtain, any need for them will be made the subject of action separate from the Five-Year Plan, not a part of it.

(i) FADS. It is the policy of Headquarters, CSG that Functional Area Descriptions are the immediate responsibility of the proponent agency and that FADS be formulated in-house by assigned government personnel. Any exception to this policy must be obtained by submitting full justification to Headquarters, CSG.

(j) Proposals to contract for Automatic Data Processing facilities will not be submitted by proponent agencies. When computer facilities are needed to complete a study, the total hours of processing time will be indicated in the proposal so that the Comptroller, HQ, CDC may make arrangements for government owned or leased facilities.

(k) Questions regarding procedures for formulating the Five-Year OR Plan should be referred to the Operations Research Branch, O&E Division, HQ, CSG, Fort Belvoir extensions 4-5950 or 4-6564.

RESEARCH AND DEVELOPMENT SCHEDULE
(SUMMARY SHEET)

Headquarters_____
(Dollars in Thousands)

Priority 69	Priority 70	Title	CDOG Ref or Other	ACN	Proponent Agency	FY70	FY71	FY72	FY73	FY74	FY75
		Category I									
		Category II									
		Category III									
		Category IV									
		Category V									
		Total FY70-75									

CHAPTER XV

MATERIEL

During the development of this Chapter, Systems and methodologies were undergoing change. When these are finalized, this chapter will be rewritten and distributed.

1. Materiel Development. The ultimate goal of combat developments is to organize and equip the Army so that it can best accomplish its mission. To achieve this goal, the Army must not only have ideas but must also have means of developing the ideas into useful hardware. The evolution from basic idea to military hardware involves three separate but interrelated processes or cycles: Materiel Requirements, Research and Development, and the Budget. USACDC has prime responsibility for the materiel requirements cycle. Materiel development preceding production may be visualized in three broad phases: concept phase, definition phase, and development phase. The time element for each phase does not end abruptly. Each phase tends to overlap the preceding and the following. Figure 1 shows the various milestones in the concept network. Subparagraph a below explains the action at each milestone.

a. Concept Phase. The concept network (See Fig 1) represents a typical project. The milestones or events shown are based on relative time with no time span indicated between events. In addition, it is nearly impossible to determine in advance where information generated in projects or tasks initiated at the start of the phase will be utilized. The data generated may have broad application to many projects or they may be of limited value. As a result, projects and tasks entering into the definition phase may originate from industry, private institutions and colleges, Qualitative Development Requirements Information (QDRI) program, and private individuals, or as a result of many in-house research projects. In other words, the goal is to maintain a technological bank from which technology may be withdrawn as necessary to support development. Not all projects will have their beginnings in research. They may be initiated at any time during the concept phase. The following paragraphs describe events and activities within each block of the concept network. Although the events and activities are shown sequentially, many actions are being performed concurrently with one or more other events or activities.

(1) Guidance Documents (block 1). The materiel life cycle has its beginning with a family of Army planning documents. The most important are the BASE, the ASP, and the AFDP. In addition, the Chief of Research and Development publishes an Army Research Plan (ARP) and a Research and Development Long Range Plan

CONCEPT NETWORK

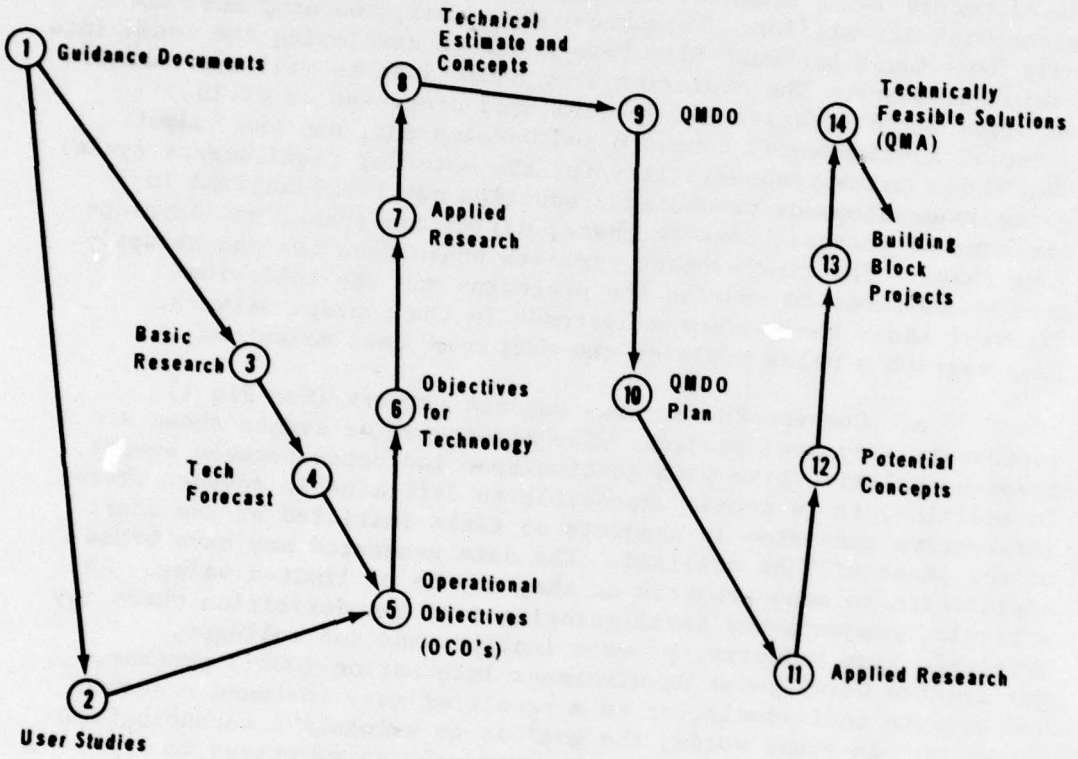

FIGURE 1

(RDLRP) which identifies scientific and technological areas of interest to the Army and describes broad objectives sought through research and exploratory development. The guidelines, objectives, and priority operational requirements contained in the above mentioned plans serve as a framework for the pursuit of work to discharge the Army's total mission responsibility. All of the plans are reviewed and updated annually.

(2) User Studies (block 2). USACDC is charged with the responsibility for originating and documenting requirements for combat materiel for the Army in the field. CDC plans, maintains, and conducts the Combat Development Study Program. Studies completed under this program culminate in new or improved doctrine, materiel and organization. Future requirements are documented in the form of broad OCO's or specific QMDO's, ADO's, QMR's and SDR's. These studies are planned and conducted within the framework of guidance provided by the Army's family of plans (see block 1): Documentation of objectives, requirements, and studies is accomplished by publishing them in the Combat Developments Objectives Guide (CDOG). CDOG, therefore, serves as the prime requirements guidance document for Army developing agencies. CDC is conducting studies and tests while AMC is performing its research and development work. CDC monitors the research and development work to obtain information on the necessary technology from which it can come up with new or revised operational objectives (See block 5).

(3) Basic Research (block 3). The US Army research and development cycle has its inception in the research projects and tasks of the research category. The basic research program is directed toward furthering the sum of fundamental knowledge in scientific areas of potential interest to the Army. The net sum of all the output of the world's basic research activities is data and theory. This, when analyzed and studied, leads to the formulation of a Technological Forecast.

(a) Any individual, unit, or agency may propose an idea or concept that might lead to establishing a research project. A developing agency may establish a research task or project provided it falls within the scope of approved plans, objectives, programs, budgets, and the assigned area of responsibility, or if it is judged proper for support under the in-house laboratory independent research program (AR 705-55).

(b) Each project or task will be submitted and justified on a DD Form 1498 (Research and Technology Resume). This will notmally be done in association with the annual RDTE budget and programming cycle, some 9 to 21 months prior to receipt of funds (AR 705-12).

(c) Project initiation and terminations must be recorded in the AMC Technical Committee minutes (AR 705-9).

(d) Upon approval and funding of a project, the actual research will be continued in the appropriate AMC laboratory or by contract with an outside agency.

(e) Research work will continue as long as the effort is promising, and enjoys sufficient priority, and funding is available.

(4) Technological Forecast (block 4). The technological Forecast, prepared by AMC under the CRD, DA, provides the operational and technical gains expected to be achievable in the period up to 20 years in the future and examples of materiel which could be provided. Volume I contains descriptions of trends and expected gains in knowledge in various scientific disciplines. Barriers limiting advancement are identified. Volume II contains a forecast of technological capabilities expected to be achievable from current and forecasted scientific knowledge if funding and programming is provided. Volume III contains materiel concepts deemed feasible in the period up to 20 years in the future if the state-of-the-art continues to advance as expected.

(5) Operational Objectives (block 5). Operational objectives are DA-approved quantitative needs for new or improved operational capabilities in the area of doctrine, materiel, and organization. They are stated in broad terms and are listed in CDOG. Operational objectives are developed by CDC, utilizing the Technological Forecast and tactical innovations generated by its doctrinal, materiel, and strategic studies.

(6) Objectives for Technology (block 6). Objectives for Technology are used for the development of technical and tactical capabilities. They provide a necessary stepping stone from the strategic and operational planning guidance of the DOD and DA General Staff to definitive, quantified statements of technological goals which may encompass a 20-year time frame. The objectives are targets and are not design limits for specific items. Achievement of the objective for one concept does not preclude the possibility of continued support of tasks which can provide equal or superior means for achieving the same objective by more simple, economical, or tactically effective concepts. Technical objectives assist CDC in its planning and formulation of recommendations for development of materiel consistent with technological achievements predicted by AMC in its Technological Forecast. This set of objectives becomes the basis for subsequent AMC research and development planning and programming actions and establishing some

of the applied research projects in the research and exploratory development categories.

(7) Applied Research Projects (Research Category) (block 7). Applied research projects are directed toward developing new and better materials and technical capabilities. These applied research projects and tasks will usually appear in the research and exploratory development categories of the RDTE program. These projects and tasks are related to the Objectives for Technology and are time-oriented applied research tasks, the successful completion of which is required before development to meet the technical objectives can be started. These time-oriented applied research tasks or projects are planned to be formed into an AMC-wide integrated task network which when associated with annual available resources will provide AMC decision makers with an indication of those operational objectives (block 5) that are likely to be met.

(8) Technical Estimates and Concepts (block 8). The output from applied research project/tasks furnishes an estimate of technical capabilities to perform the functions necessary to satisfy the operational objectives and to indicate any new materiel concepts which appear feasible. Technical capabilities indicate the technical capacity to perform a function, having potential utility in military materiel systems, to a given precision or range of precisions under a specified range of conditions. The ability to scale the precision or magnitude of performance over a range which can be predicted as being useful for military end item development completes establishment of the technical estimate and establishes the point at which it is logical to terminate the applied research projects/tasks as applied to specific functions. The information gained can then be used by the developer in development projects, and by CDC in establishing QMDO's.

(9) Qualitative Materiel Development Objective (QMDO) Approved (block 9). The first formal requirements document that the Army uses in the research and development cycle is the QMDO. Any individual (military or civilian), unit, or agency may propose a concept or idea that might lead to establishing a QMDO. However, CDC is delegated the authority and responsibility for preparation and submission of QMDO's to ACSFOR for approval. CDC uses operations research techniques to relate future tactics to the technical estimates and concepts furnished by AMC as a result of its basic and applied research work. From this point on all research and development must be supported by requirements document such as a QMDO, ADO, QMR, or SDR unless otherwise directed by appropriate DA authority. Prior to this time, the family of Army plans could be used as authority to initiate projects or tasks. Sometimes, QMDO's are initiated earlier in the cycle at the time the operational

objectives are established (block 5). Since the QMDO and its implementing plan sets the guidance for future programming and funding of research and development concepts and systems, it is a major decision point in the cycle.

(10) QMDO Plan (block 10). Upon approval of the QMDO, the CRD assigns responsibility to AMC for research and development work. AMC will then assign responsibility for the QMDO to one of the subordinate commands or laboratories on a sole, prime, or attendant basis. The designated development agency will prepare and coordinate with other developing agencies that have competence and responsibilities in the area concerned, a brief but specific plan that outlines all the research and development work that is required to prove out the feasibility of the QMDO. (See AR 705-5 for information to be included in the plan.) The plan summarizes existing research projects and tasks, states an estimate of the additional projects and tasks required to achieve the technological capability, and gives an estimate of the research risks involved in each approach. Cost estimates are also included. The QMDO plan is coordinated with USACDC.

(11) Applied Research (Exploratory or Advanced Development) (block 11). The applied research work involved in these projects and tasks is directed primarily toward filling the gap in technology as outlined in the task networks of the QMDO plan and to evolve potential concepts in order to determine the degree of feasibility of the QMDO.

(12) Potential Concepts (block 12). As work progresses in the applied research projects and tasks, information and data are generated from which potential concepts can be generated. Each potential concept is expected to contain a description of the technical risks associated with the feasibility of attaining the technical characteristics, the level of military effectiveness resulting from these characteristics and a rough cost estimate. The cost extimate will serve to indicate those concepts that are inordinately expensive and will provide a means for AMC/CDC to ultimately evaluate high cost versus urgent military need. These potential concepts when followed up by component development projects or tasks in the exploratory or advanced development category, will lead to technically feasible solutions.

(13) Building Block Projects (block 13). Building block projects and tasks are the efforts extended to develop subsystems or components that can be utilized in one of the potential concepts that have been determined in block 12. They consist of exploratory and advanced development work falling within the development class. It is here that efforts are expended to engineer

and refine the concepts to determine technically feasible solutions that satisfy the QMDO. These projects/tasks are continued until the best technical solution has been selected and the project is approved to go into the engineering or operational systems development category. At this time, engineering is about all that should be required to end up with a hardware item or system.

(14) Technically Feasible Solutions (block 14). As a result of the "building block" work, one or more technically feasible solutions may be evolved, that can be developed in a specific time period if adequate resources (funds, facilities, and personnel) are made available. These solutions when forwarded to CDC in the form of a Qualitative Materiel Approach (QMA) afford the basis for initiating an ADO or QMR. An analysis of the various technical solutions is usually done in the concept selection process where all factors are considered before selecting the best course of action to be followed in going into full scale development. This event normally completes or terminates the concept phase.

b. Definition Phase.

(1) Definition. The definition phase immediately precedes and leads to the development phase. It is established to provide a logical procedural step for accomplishing an orderly transition from the conceptual to the development phase. It includes contract definition phase referred to in DOD directive 3200.9 and AR 705-5. The definition phase systematically translates technological advances into total system design requirements to be met in the development phase. It also serves to insure that full scale development is not started until costs, schedules, and performance objectives have been carefully thought out and evaluated against one another and that a high probability of successfully accomplishing the full-scale development phase is anticipated. The definition phase permits the orderly planning, programming, and budgeting of new development items or systems. It is also normally, the time during which the QMR/SDR's are prepared and approved.

(2) Nature of Work. Work in the definition phase consists entirely of effort supported by the exploratory and advanced development categories of Program IV, Research and Development. Preliminary engineering and contract and management planning are accomplished to assure that management decisions to proceed with, cancel, or change development projects are made on a total system and total cost basis which includes realistic cost and schedule estimates and achievable performance specifications. The definition phase affords the developer an opportunity to perform trade-off analyses, cost-effectiveness studies, and system analyses; establish improvement coefficients; examine the project to see that the necessary building blocks (components) are available; and select the best technical approach.

DEFINITION PHASE NETWORK

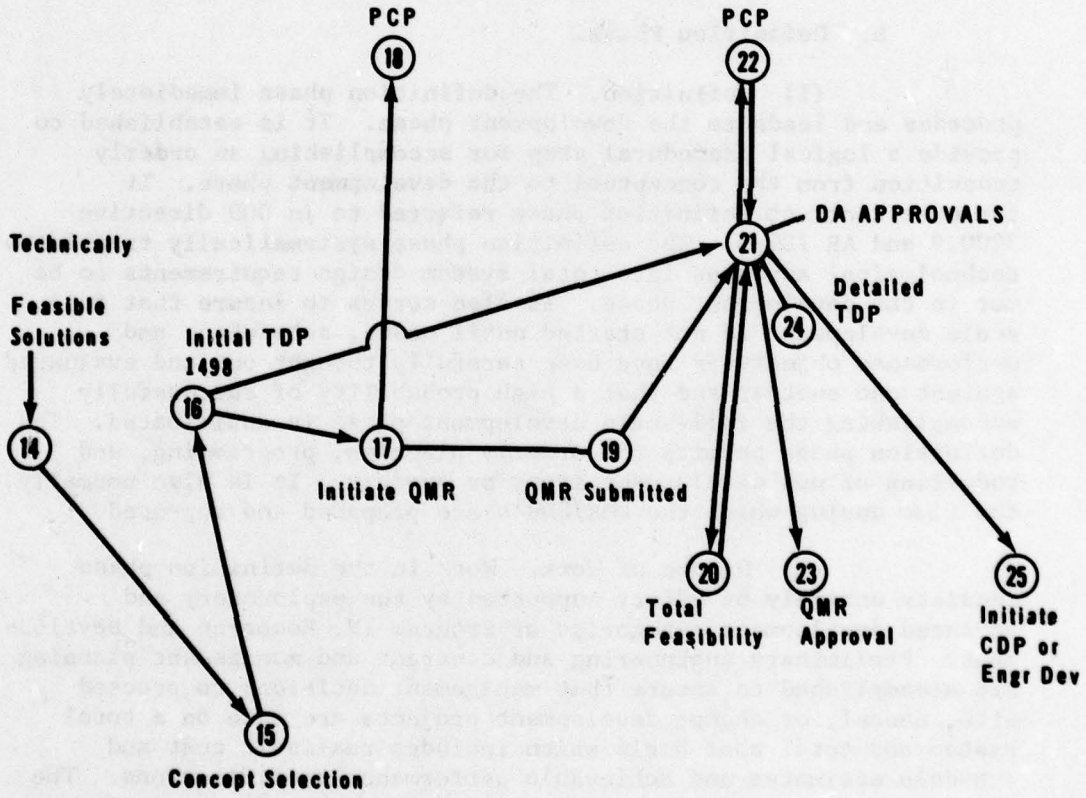

FIGURE 2

(3) Definition Network. The definition network at Figure 2 represents a typical project. The network is not time-framed; however, on the average, this phase lasts about 2 years if Contract Definition is not required or 2½ years for projects requiring Contract Definition. The following paragraphs describe events and activities within each block of the definition network (See Figure 2).

(a) Concept Selection (block 15). The purpose of the concept selection is to choose the most promising technically feasible approach for developing a major item or system. It is a joint developing agency-CDC effort. The selection will include a review of prior technical feasibility studies and is required to be prepared as a study for all projects going into formal contract definition phase. It may be used for other projects if determined appropriate by the commanders concerned. The concept selection study should generate, as a minimum, a cost effectiveness study, a system analysis, and information necessary for assembling, evaluating, and preparing the technical and managerial data required for the preparation of the QMR and review of the project by CRD and the Materiel Requirements Review Committee (MRRC), if appropriate. The concept selection process is intended to provide information for AMC to prepare a detailed Technical Development Plan (TDP) (block 24) of DD 1498, and for CDC to prepare a QMR (block 19). It also aids all Army elements in evaluating, improving, and/or modifying the project and its associated QMR. Concept selection is a major decision point.

(b) Initial TDP or DD 1498 (block 16). The initial TDP or DD Form 1498 is used for programming purposes in order to obtain program approval on a timely basis. The leadtime on programming is from 9 - 21 months prior to the start of the fiscal year. It is to be used, for planning purposes only, in obtaining PCP approval for any year or years beyond the budget year. Information needed will be assembled as soon as the best technical approach(s) has been selected either from the concept selection process or from the technically feasible solutions. The technical approach will contain only that information needed by the Office of Secretary of Defense to approve the PCP for planning purposes. The detailed technical information will be included later upon completion of the concept selection process in the detailed TDP or DD 1498 (block 24).

(c) Initiate QMR (block 17). USACDC is responsible forpreparation and submission of all QMR's. A QMR is a DA-approved statement of a military need for a new item, system, or assemblage, the development of which is believed feasible. Any agency may prepare a draft QMR and submit it to CDC for review and

coordination. For projects for which a concept selection study is being conducted, the QMR should be initiated concurrently with the study as data is generated. The proposed QMR is sent to the developing agency who reviews, coordinates, makes comments, and/or concurs, and then returns the proposed QMR to CDC.

(d) PCP Approval (block 18). The PCP is the document which proposes new program elements or changes to program elements already entered into the approved Fire-Year Force Structure and Financial Program (FYFS&FP). The purpose of the PCP versus the one shown in block 22 is to obtain program approval for planning purposes only and is based on minimum OSD technical and mission requirements. The PCP in block 22 carries budget approval and requires an approved QMR and a detailed TDP. The PCP is normally submitted to DA some 9 to 21 months prior to the release of funds. At this time, a project manager may be appointed and initial staff planning started for project take-over.

(e) QMR submittal (block 19). The net result of a favorable concept selection study is information on which to prepare a QMR and a detailed TDP. The QMR is prepared by CDC, coordinated with major commands including MAC, and submitted to OCRD, DA, for approval. Average coordination time within AMC is about four months. During this coordination time, AMC's developing agencies should prepare the technical characteristics and formulate the TDP. It may be updated later either after formal contract definition, or after the technical characteristics inprocess review.

(f) Total Feasibility (block 20). Total feasibility includes consideration of technical feasibility; system effectiveness; availability of funds throughout the life cycle; qualitative and quantitative personnel implications; operational and organizational concepts; logistical support implications; and impact upon inventory, including phase-out of items being replaced and forecasted availability of new items. Total feasibility is the DA General Staff in every case and by the Materiel Requirements Review Committee (MRRC) for major or controversial items or systems.

(g) Department of Army Approvals (block 21). Actions included in this effort include review, staffing, and approval of the TDP, QMR, and PCP. Various DA staff agencies are involved as well as the MRRC. Generally, the TDP and theQMR are handled and staffed separately for review and evaluation prior to approval or disapproval by DA. Both of them, however, are used in support of the PCP in obtaining approval from OSD. The QMR will usually be approved independently whether or not the TDP or PCP is approved. The average processing time for a QMR at DA level is about four months.

(h) PCP Approval (block 22). This PCP is required for major projects exceeding decision thresholds. For such projects, it secures DA and OSD approval required before full-scale development can be undertaken. The purpose of the PCP in block 18 was to place the project in the FYFS&FP but did not serve to obtain budget approval. This initial PCP merely obtained advanced approval for planning purposes of a promising project to be eventually placed in engineering development and/or operation systems development. At that point in time, insufficient data had been generated in exploratory and advanced development to submit a detailed TDP and the Army had not furmed up its military requirement. For sub-threshold projects (projects for which DA has approval authority) another PCP at this time is not normally required: an up-dated TDP or Form 1498 is used to obtain the release of funds.

(i) QMR Approval (block 23). Upon approval of the QMR, the CRD will notify the CDC, and the AMC. CDC will then publish the QMR and see that it is placed in the Combat Development Objectives Guide. The CRD will also direct AMC to initiate a project provided the PCP is approved and the necessary funds have been released (block 25).

(j) Detailed TDP or DD 1498 (block 24). The TDP presents a comprehensive plan for development of a system. It is the prime basis for approval, disapproval, or modification of the project it describes and is the approved plan for execution by the Army. The plan consists of four parts as listed at para 9b(3) and is prepared by the developing agency for each project and major task designated by CRD. A DD Form 1498 may be used for all other projects not requiring a TDP. The TDP is a very important document especially from the AMC standpoint. It is here that for the first time AMC has the opportunity of considering as an entity the factors of scheduling, performance design characteristics, and contracting. Additional factors considered on a continuing basis are the management plan, configuration management plan, test and evaluation plan, personnel and personnel training plan, logistics support plan, facilities, foreign technology, planned production, and technical documentation. The TDP and DD Form 1498 will be updated and changed as required by AR's 705-12 and 70-9. Information in the TDP is used to help support the PCP (block 22) in obtaining project and budget approval and in determining total feasibility for approval of the QMR.

(k) Initiate Contract Definition or Engr Development (block 25). This activity completes actions in the definition phase except in those instances where projects undergo formalized CDP. At this point in time, if a CDP is not required, funding moves from the exploratory or advanced development categories to

the engineering or operations system development categories. Upon approval of Engineering development, Headquarters, DA, will assign a project number, and direct AMC to initiate a project responsibe to the approved requirement, and indicate whether formal in-process reviews are to be required. This milestone is completed when the project has been recorded by the AMC Technical Committee (AR 700-20 and AR 705-9).

c. Development Phase.

(1) Definition. The development phase is the period during which engineering and testing is performed to come up with an end item or system which satisfies a military requirement. The main product of research and development is information which can be provided to a production organization for use in producing the item which has been developed. The equipment which is constructed during research and development is incidental to the real product and serves only to test the effectiveness of the research and validity of the data.

(2) Nature of Work. Work in the development phase consists entirely of effort supported by the engineering development and/or operational systems development categories of Program VI, Research and Development. A project may be carried in engineering development until it is type-classified as standard. However, if the force structure and logistical plan has been approved along with a complete doctrinal-materiel-organizational package, the project will then be transferred to the operational systems development category. This will then permit concurrent production planning and expenditure of procurement funds while development is being carried out. Normally, Advanced Production Engineering (APE) funds will not be made available unless the item or system is scheduled for procurement in the Army Materiel Plan and is listed in the AFDP. Ideally, a decision to enter the development phase should be a production decision to buy upon satisfactory completion of development. In order to be in a position to buy at the end of development, both PEMA and OMA funds must be allocated on an annual basis for APE and training a minimum of 3 years prior to type classification.

(3) Development Network. The development network at Figure 3 represents a "typical" project. It does not show all of the milestones and activities which may be required for a specific project. Likewise, not all events listed on this network are applicable to all projects. The network is not time-framed; however, on the average, the development phase lasts about 4 years. The network illustrates a project going through five IPR's, the fabrication of a prototype for engineer design testing, and then procurement of prototypes for concurrent or integrated engineer

DEVELOPMENT NETWORK

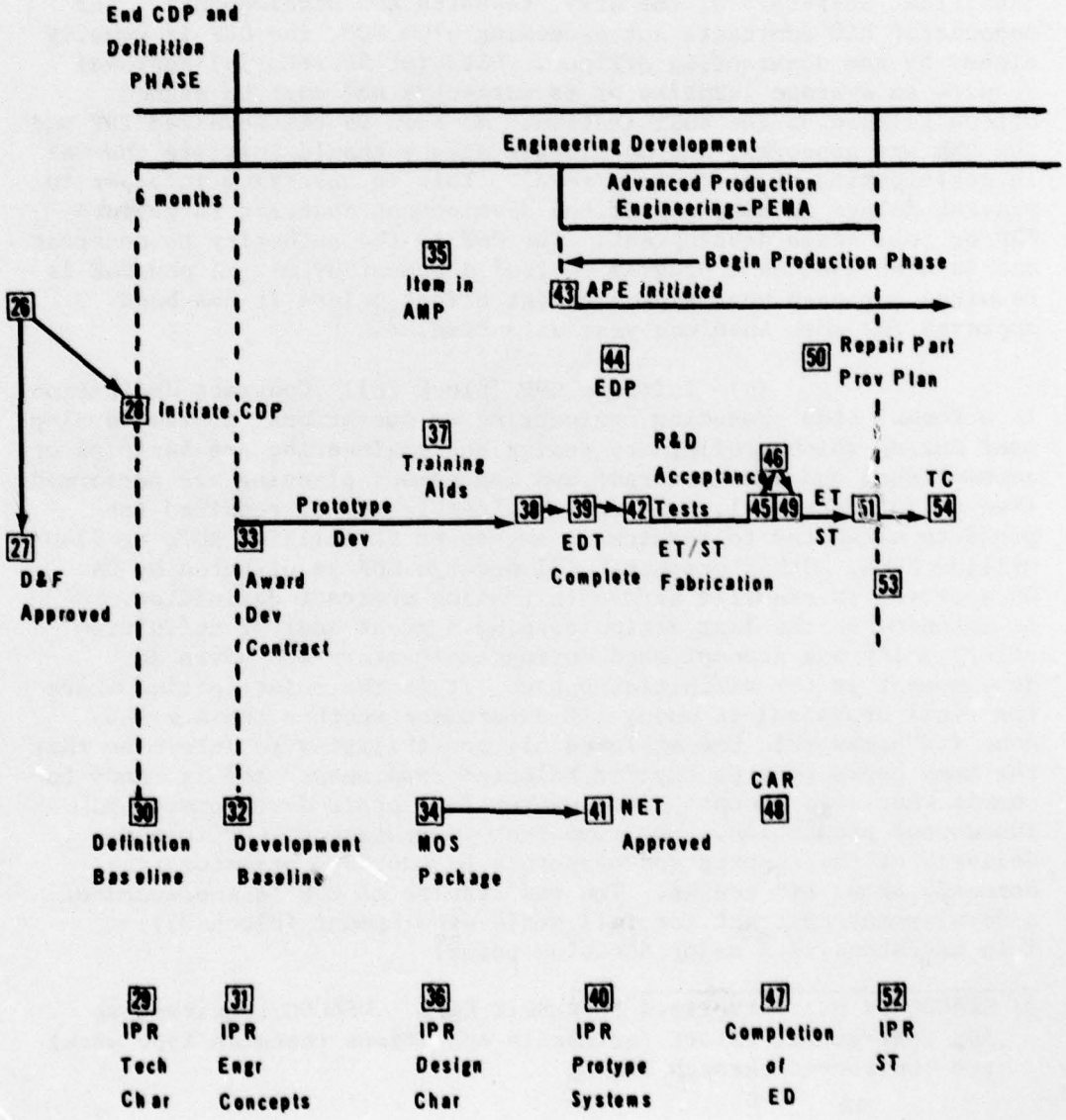

FIGURE 3

and service test. (If sequential testing is performed, leadtime will be increased by about 4 months.) The following paragraphs describe events and activities within each block of the definition network.

(a) Determination and Findings (D&Fs) Approved (block 27). An approved D&F is required as authority to enter into a contract by negotiation. For negotiated R&D contracts in excess of $100,000, the D&F requires approval of the Secretary of the Army (Assistant Secretary of the Army, Research and Development). For negotiated R&D contracts not exceeding $100,000, the D&F is usually signed by the contracting officer. D&Fs for Secretarial approval require an average leadtime of 68 work-days and must be signed before release of the solicitation. As soon as the detailed TDP and the QMR are approved, the developing agency should initiate the D&F in anticipation of project approval. This is necessary in order to prevent delays in awarding of the development contract to go into CDP or full scale development. The D&F is the authority to contract and is also used as a program control document by DA. A new D&F is required for each year's development effort unless it has been approved for more than one year at a time. 3/

(b) Initiate CDP (block 28). Contract definition is a formal step preceding engineering or operational system development during which preliminary design and engineering are verified or accomplished and firm contract and management planning are performed. (See AR 705, Change 1, for prerequisites.) CDP is required for projects estimates to require in excess of $25 million RDTE or $100 million PEMA. Other projects will undergo CDP as directed by DA. DA approval is required before initiating contract definition. CDP is intended as the last action capping a great deal of definition effort which was accomplished during exploratory and advanced development in the definition phase. It is the point-in-time where the final appraisal is made. It determines whether the Army has done its homework; has explored all possibilities to determine that the Army knows what to buy for balanced readiness; and is ready to commit the large amounts of money for full scale development and subsequent production. The time from initiation of CDP to the delivery of the reports and proposals by the CD contractors is normally about six months. The end results of CDP is the award of a development contract for full scale development (block 33). This milestone is a major decision point.

3/ USACDC is not authorized to submit D&Fs. USACDC requirements for contractual effort (primarily operations research type work) are contracted through USAMC.

(c) Technical Characteristics In-Process Review (block 29). After the QMR has been submitted to DA, and while it is being staffed, the technical characteristics should be prepared by the developing agency. This is necessary in order to save administrative leadtime and to be prepared to conduct the technical characteristics in-process review shortly after project initiation. The IPR package should be in the hands of the participants at least 15 workdays prior to the review meeting. The technical characteristics review assures that the developer understands the requirements and has properly stated the requirements in terms of technical characteristics. The minutes of the meeting are recorded in the AMC Technical Committee as a read-for-record item and distributed to the participating and interested agencies 15 workdays after the review. While the technical committee is not a decision-making body, it assists in the timely coordination and staffing actions. The technical characteristics, once approved by DA, are then used for full scale development either in-house or by contract. Approval of the technical characteristics also establishes the point-in-time when configuration management becomes a major consideration and a definition baseline should be established.

(d) Definition Baseline (block 30). The definition baseline is the first of three baselines established to provide a basis for configuration control and status reporting. These baselines are an integral part of configuration management. They are reference points to which all engineering changes (or waivers) are specifically related. Baselines are defined by system descriptions (definition baseline) development descriptions (development baseline) or production descriptions (production baseline) respectively. (The definition baseline is established after approval of the technical characteristics and before release of requests for proposals to contractors.)

(e) Engineering Concepts "In-Process" Review (block 31). The Engineering concept review is the second of five in-process reviews held during the developing phase. It is conducted upon completion of the engineering concept to insure that the contractor or in-house facility is not commencing a program that is beyond the state-of-the-art or contains too many risk areas. It is held after the reports are received from the contractors on the funded portion of CDP and prior to award of full-scale development contract. For those developments that do not go through CDP and are performed "out-of-house" it should be held before finalizing the award of the development contract to industry. For work performed in-house it should be held after finalizing the engineering concept and prior to actual prototype hardware or model fabrication.

(f) Development Baseline (block 32). The development baseline must be established prior to the initiation of full-scale development of a system or its components. The development description(s) documenting this baseline depict the performance and available design requirements for hardware design and fabrication.

(g) Award of Development Contract (block 33). The award of a contract for full-scale development, culminates a great deal of concentrated effort on the part of the developing agencies. It is the time of test to determine how well the Army performed in the preceding phases. If the homework is done properly, there should be little or no technical advances during the development phase since the technical risks are relatively low. The award of the development contract is a major decision point.

(h) Coordinated MOS Package Submitted (block 34). The CONARC-CDC-AMC coordinated MOS package identifies the knowledge and skills required of personnel for the operation and maintenance of an item. The QMR contains the initial information concerning MOS requirements. As development progresses, the developing agency gathers additional information and evaluates overall MOS requirements and coordinates this data with CONARC and CDC. The CONARC-CDC-AMC coordinated MOS package should be submitted to HQ, AMC prior to the design characteristics "in-process" review (block 36).

(i) Item in Army Materiel Plan (block 35). The Army Materiel Plan outlines the Army's procurement plans for major and secondary items and high cost repair parts. The plan is established to provide a medium through which the Army can project its mid-range materiel program. The eight year period of this plan covers the prior fiscal year, the current fiscal year and the succeeding six fiscal years. The plan is designed to integrate those elements of logistics which directly affect Army materiel, i.e., procurement, deliveries, research and development, supply and distribution, production facilities and engineering, repair, overhaul and maintenance, losses and disposals and oblication and expenditure levels. The purpose of the plan is to maintain balanced inventories and to meet established objectives. It is closely aligned with the AFDP. (Guidelines for preparation of the AMP are contained in a DA publication titled "PEMA Policy and Guidance".) The AMP contains a DA Form 2624 for each end item which provides on the development status of each item or system. This information includes a description of the item, the developer, unit cost in production, basis of issue by table of organization and equipment (TOE) and table of allowances (TA), and related items in inventory. The AMP is a very important document from the standpoint of the developer because failure to program an item in the plan on time will deny use of PEMA funds for production engineering. Similarly,

if a basis of issue is not prepared, gross requirements cannot be completed and, hence, the item cannot be procured. Establishment of a firm basis of issue requires a leadtime of 1 to 1½ years.

(j) Design Characteristics "In-Process" Review (block 36). This IPR is generally held after a wooden mock-up or model has been built. The purpose of the IPR is to verify design characteristics before fabrication of metal prototypes.

(k) Development Initiated for Required Training Aids (block 37). Training aids and devices are items designed to demonstrate a concept or to provide a symthetic situation in which human skills and techniques are developed or improved. Training devices have but one function and that is to assist in the transfer of learning. CONARC is responsible for proposing SDR for training devices to CDC and for monitoring training device development. (Ref para 6F, AR 705-5.) USAMC, upon receipt of the SDR, coordinates with the Army Participation Group, US Naval Training Device Center (USNTC), to determine their capability to develop the training device. Sources other than USNTC will be utilized only after a formal determination is made that USCTC cannot provide the services in the time frame required and within available funds. (AMC Regulation 350-12.)

(l) Completion of Prototype Fabrication (block 38). This activity signifies the completion of fabrication of the first design model(s) or prototype(s) to be used for engineer design testing and maintenance evaluation tests.

(m) Engineer Design Test (EDT) Completed (block 39). Engineer design tests are conducted by or under the control of the design agency to determine inherent structural, electrical, or other physical and chemical properties of construction materials, item, or system, including the effect of environmental stresses on these properties. The purpose of the tests is to collect design data, confirm preliminary concepts and calculations, and determine the capability of components. In the case of a highly complex system consisting of a number of major integrated components, the EDT may be expanded to include a complete system demonstration. Here, following component or subsystem testing, the design agency demonstrates the engineering feasibility of complete systems operation. Testing is usually done on a system or item by separate components or subassemblies as soon as they are fabricated and delivered by the contractor.

(n) Prototype System In-Process Review (block 40). The prototype system IPR is the fourth of five IPR's that are required to be conducted in the development phase. It is held after

completion of the engineer design tests and before fabrication starts on the engineer and service test models. Its primary purpose is to afford all interested parties a chance to see the actual hardware perform as a complete system and compare it with the physical and performance characteristics outlined in the QMR. Successful completion of the IPR permits continuation of development fabrication of engineer/service test models or prototypes.

(o) New Equipment Training Program Approved (block 41). This program is a planned approach to satisfy the personnel and training requirements for each item or system. All the personnel and training requirements for each item or system. All the personnel and training activities are identified and interfaced with the development, production, and distribution milestones for each component or subsystem. The program establishes planned time frames for preparing and conducting staff planners' courses and technical training courses; preparing new materiel introductory letters; and organizing, training, and dispatching new equipment training teams.

(p) Award of ET/ST Prototype Contract (block 42). This activity is not required when the original contract (block 33) included prototypes for engineer and service test. It is required where a prototype is first fabricated and then tested before a decision is made to go ahead with development. In most cases the same contractor that fabricated the first prototype will get the contract to build the test prototypes for engineer and service testing. In addition, a Determination and Findings will be required. Administrative leadtime for D&F processing, receipt of proposals, and evaluation and negotiation of a contract is normally about 5 to 6 months.

(q) Advanced Production Engineering (APE) Initiated (block 43). This is the beginning of the production phase. Normally, as shown here, it runs concurrent with and overlaps the development phase. APE may beinitiated at any time during the development phase when the research and development design is sufficiently stable and funding is available. It will usually be initiated after the engineering design test and the prototype system IPR have been completed. APE includes advising design and development engineers on material productibility, including such factors as standardization of components and assemblies, and economy of materials. It also includes development of special production equipment, tools, fixtures, and jigs; establishment, operation, and support of pilot production lines to prove capability to produce; and validation of the technical data package and quality assurance procedures for equipment to prove that production materiel meets established requirements. Studies may also be conducted to devise new or improved

manufacturing methods and techniques to reduce production costs, reduce item lead time, and improve process reliability or assure materiel productibility. Initiation of Advance Production Engineering is a major decision point.

(r) Equipment Distribution Plans (EDT) Initiated (block 44). Equipment distribution planning studies provide an approved distribution plan for each new combat-essential end item from the time it is initially included in the approved Army Materiel Plan until it is ultimately disposed of from the Army supply system. These studies establish control over both current authorizations and projected equipment needs resulting from programmed or approved unit actions and contingencies such as activations, reorganizations, and prepositioning actions.

(s) Completion of ET/ST Fabrication (Block 45) This activity is completed upon satisfactory completion of prototype fabrication of models to be used for engineer and service tests and initiates research and development acceptance tests (block 46).

(t) Research and Development Acceptance Tests (block 46). Research and development acceptance tests are tests conducted by or under the control of the developing agency on an item or system designed and developed by a contractor to insure that the requirements of the development contract have been fulfilled and the item or system is acceptable for further testing by US Army Test Evaluation Command (USATECOM).

(u) Completion of Engineer Design (ED) (block 47). Engineer design is completed when the test prototypes have been shipped to the testing agency (USATECOM) for engineer and/or service test. By this date, design studies, drawings, experimental mock-ups, and design testing will have been completed.

(v) Configuration Audit Review (CAR) (block 48). The configuration audit review is a technical audit conducted by the developing agency during which available documentation is compared with prototype hardware to assure its accuracy and adequacy and its conformance to the Development baseline description. The CAR is normally initiated prior to start of engineer test/service test (ET/ST) but is not completed until after the service test IPR.

(w) Initiate ET/ST (block 49). Engineer and service tests are conducted by or under the supervision of USATECOM. The objective of the engineer test is to determine the technical performance and safety characteristics of an item or system and its associated tools and test equipment as described in the QMR and the technical characteristics. The engineering test provides data for

use in further development and for determination as to the technical and maintenance suitability of the item or system. The service test, on the other hand, has as its objective the determination of whether or not the item or system satisfies the QMR and is suitable for use by the Army. It provides a basis for recommendations for type classification. (AR 70-10 and AMC Regulation 70-7.) Normally, engineer tests and service tests are performed concurrently or on an integrated basis. The average test time on each is about 90 work days to prepare the reports and recommendations.

(x) Repair Parts Provisioning Plan (block 50). The repair parts provisioning plan determines the requirements for repair parts, special tools, test equipment, and support equipment to support and maintain an end item of materiel for an initial period of service. This plan includes the identification of items of supply; the establishment of data for catalog, technical manual, and allowance table preparation; and the preparation of instructions to assure delivery of necessary support items with related end items. The plan is completed upon approval by the commodity commander responsible or by DCSLOG if repair parts requirements exceed delegated authority (AR's 700-70 and 700-19).

(y) Completion of Service Test (block 51). The ST is complete when the ST report has been prepared, coordinated and recommendations forwarded to DA.

(z) Service Test In-Process Review (block 52). The service test IPR is held upon completion of the service test or the integrated engineer and service tests and is conducted in order to arrive at a recommendation concerning adoption of the item or system as standard, or planned action to remedy shortcomings and deficiencies found in test. The minutes are recorded in the AMC Technical Committee (AR 70-10 and AR 70-9).

(aa) Operational Systems Development (block 53). As previously discussed in subparagraph 10c(2), not all projects will go into operational systems development prior to type classification. Entry into the 6.71 category, in effect, represents an approval for production before the development phase is complete. Operational systems development is considered by OSD as that effort needed to convert the design engineering products of engineering development into purely productionized systems and equipments. The design data package from engineering development, supplemented by the production engineering data package from operational systems development, should result in an acceptable data package for competitive procurement and operational usage.

(bb) Type Classification (TC) (block 54). This activity formally ends the development phase. Type classification is the categorization of an item or system according to its suitability for service use.

2. Summary:

a. The purpose of research and development is to provide the Army with the best equipment at realistic cost. While reduction of leadtime is a desirable goal, research and development is by nature time oriented, and if compressed beyond a certain point will result in inferior equipment at astronomical costs. Improved management offers the best hope of maintaining an acceptable balance between these two essentially conflicting requirements for speed and economy.

b. The materiel requirements cycle, research and development cycle and the budget cycle are integrated through planning, programming and budgeting.

c. Program VI of the FTFS&FP parallels the DOD Program VI and serves as a bridge between planning and budgeting. The six categories of development represent, in a simplified way, the evolutionary process by which ideas are converted into hardware. An approved materiel requirements document is only one of the several prerequisites for moving a project along this development scale.

d. Decision-making under the present system entails changing the approved program in some part. DA has the authority to make decisions (change the program) only to the extent that these changes do not violate the thresholds established by DOD.

e. To facilitate understanding the total process of materiel evolution short of production, may be visualized as occurring in three broad phases: Concept Phase, Definition Phase, and Development Phase.

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